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JOURNAL
OF THE
AMERICAN PEAT SOCIETY

A QUARTERLY JOURNAL DEVOTED TO THE DIFFUSION OF KNOWLEDGE OF THE UTILIZATION OF PEAT, AND THE DEVELOPMENT OF AMERICAN PEAT RESOURCES.

VOLUME XI.

JANUARY, 1918, TO OCTOBER, 1918.

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Mr. Chas. Knap, Secretary,
American Peat Society,
Whitehall Building,
New York City.

Dear Sir:—

I, the undersigned, being interested in the development of our peat resources and in the welfare of the peat Society, beg to make application to membership in your Society, for which I enclose \$5.00 as annual dues.

Signed

Address

Date.....

Journal of the American Peat Society

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Julius Bordollo

Julius Bordollo, initiator, charter member, life-long Secretary of the American Peat Society, died at his home in New York City November 7, 1917.

The members of the American Peat Society, especially those serving in an executive capacity, will greatly miss his presence and helpful enthusiasm. Now more than ever are we able to see that our lives are merely part of a scheme for the up-lift of humanity. We cannot help the feeling that Mr. Bordollo's spirit is still working with us to help accomplish the aim for which this society was founded, even though his physical presence is gone. Julius Bordollo, though German born, was a patriotic American citizen, having one son in the Army and one in the Navy. He had imbibed the American spirit of optimism and faith in everyone. His cheery greeting was an outward sign of his heart's good will for others.

The executive committee have assumed the duties of his office until a new secretary and treasurer can be appointed to serve till the next annual meeting. It would please Mr. Bordollo to know that the whole membership of the Society was showing the same friendliness and cooperation to his successor that they have shown to him.

Items of Interest

Delaware.

Prof. Thos. F. Manns, of Delaware College Agricultural Experiment Station, states that the deposits in his State are of little commercial value. Most of the peats in Delaware are along the coast and are salt-marsh peats which are poorly decomposed and not very deep, usually supporting marsh grasses. These grasses are being shipped to larger markets at fairly good prices. There are no muck lands being used for trucking. This indicates that Delaware has practically no inland peat deposits of value.

Illinois.

Prof. J. G. Mosier, of the Illinois Agricultural Experiment Station, states that there are considerable peat deposits in the State of Illinois. In Lake County there are 38 square miles of peat of varying depth, and other counties in the northern part the State have large areas. It is being used for raising crops, and with the aid of potassium salts and thorough drainage, this type of soil becomes quite productive. Most of it, however, is in pasture and this is perhaps one of the best ways at present for utilizing it in agriculture. There is one place in the State of Illinois where peat is being gotten out and used as a filler for commercial fertilizer. It is used locally on a small scale in certain parts of the State for bedding but only in limited amounts. There is one place where the peat is of such a character that it is used for packing. Attempts were made at one time for burning peat, but this did not prove economical because of the competition of coal.

Michigan.

Prof. C. S. Robinson, of the Michigan Agricultural College, states that during the past three years a decided interest in the increase of muck lands of Michigan has been manifest and as a consequence the agricultural college has taken up the matter from some new points of view. Some time ago a man was appointed to study the question of the diseases of crops usually grown on muck soils and to instruct the growers of these crops in the best methods of preventing such diseases. Special attention was paid to the celery and lettuce crops. So successful was the venture that the title of the position has been changed to Extension Specialist in Muck Crops and the scope of the work widened to include all the problems in-

volved in the utilization of muck lands through the cooperation of other departments of the college. The man who is at present engaged in this work is Mr. Ezra Levin, of the Department of Botany. Mr. J. Frank Morgan, of the Department of Bacteriology, has just started a series of investigations on the bacterial changes in peat-manure composts.

New Jersey.

Prof. Jacob G. Lipman, of the New Jersey Agricultural Experiment Stations, reports on the activities of peat in his State: The most important commercial utilization of peat in New Jersey is carried on by the Alphano Humus Co. The Hyper Humus Co., of Sussex County, is marketing some peat. Other developments are largely in using peat for agriculture. A considerable area of muck land is being developed off Hasbrouck Heights, in Bergen County, N. J., and along the coast the salt-marsh areas that have been ditched for three years or more are producing profitable crops of salt hay.

New York.

Prof. R. C. Collison, of the New York Agricultural Experiment Stations, says that little has been done as yet on the mucks and peats of New York. He believes that their importance in this State warrants extensive investigation as to types, composition, crop adaptation, and general utilization. He says that this work logically falls under his supervision but as he has a year's leave of absence he will be unable to take up work of this kind at present, but on his resumption of station duties, he may take up some work along these lines. The only really large project of which he knows at present is the one being carried on by the Western New York Farm Lands Co. at Elba.

Oregon.

Prof. C. V. Ruzek, of the Oregon State Agricultural College, says that up to the present time no systematic survey has been made of the peat soils in Oregon. Where such soils occur near the large cities, they are now being farmed intensively with trucking crops and are very profitable. Phosphate and potash compounds in the form of commercial fertilizers give good returns on both of these soils. In the eastern and central sections of the State where irrigation must be practiced in order to grow crops, most of the native meadows are marsh soils, the centers of which are composed of peat soil. These soils when drained and then irrigated are seeded to cultivated grasses, and grow a much better type of grass than when left in the native condition. On account of the large

timber areas in his State he doubts whether peat will be used for fuel for some considerable time.

Pennsylvania

Prof. William Frear, of the Pennsylvania State Experiment Station, states that the State of Pennsylvania has, particularly in its glacial regions, numerous small lakes of glacial origin. Of these, some of the shallower have been filled with peat deposits. The areas of single beds are never great, but collectively the area of peat deposits is doubtless considerable. There has been, however, no official survey of the State's peat resources. Whenever asked so to do by the owners of such peat beds, the Experiment Station has undertaken to make partial analyses of their products; and has in each case endeavored to procure information concerning the areas and depths of deposits represented, and also to gain such hint of the probabilities of purity of the beds in general as could be obtained by topographical data relative to surroundings that would serve to indicate the probability of large amounts of wash from surrounding hills being discharged into the peat pockets. He has not personally examined all the samples but he knows that a large number of them are moss peats, seemingly sphagnum. It is his purpose presently to write as an Experiment Station publication some account of the data collected, upon the plan above mentioned, through the many years of the Station's work.

Rhode Island.

Prof. Burt L. Hartwell, of the Rhode Island Agricultural Experiment Station, states that although the station's experience with peat or muck has been of too short duration to warrant publishing results, it may be interesting to know what is being undertaken. In connection with market-garden rotations muck composted with lime is being used in one test. One large application of about 80 cords of muck composted with 10 tons of lime was tried. It is not expected to repeat this application in the near future. In another test muck is being added each year so as to supply the same amount of organic matter as is contained in a ton application of horse stable manure. The limestone in this test has been applied to the soil but the reaction between the limestone and the muck will perhaps prove to be too slow, so that the latter may be neutralized for sensitive crops like lettuce. So far the experiment has not been very promising and probably hereafter the lime will be composted before application. In another experiment a large amount of muck composted with lime previous has been used in seeding down for a lawn. The results will

be compared with those from other treatments. Again, in the greenhouse an attempt will be made to grow lettuce on a mixture of muck composted with lime, sand, and fertilizer chemicals, avoiding entirely putrid decomposing organic matter such as is contained in manure, the idea being in part to determine whether any development takes place regarding disease. Cucumbers will probably follow lettuce in this test.

Washington.

Prof. Chester C. Farr states that there is a great deal of peat land in Snohomish County, in which he resides, and that he is sure that there are some peat lands which are of the right age for commercial use, having so far not gone through any rot stages. At present no commercial uses are made of this material.

Prof. L. S. Keyes states that there are several areas of partly decomposed beaver-dam and peat soils in Cowlitz County. There is also a considerable body, probably 1,000 acres, of raw undecomposed peat. This is formed by a broad-leaved marsh grass and another plant known as "marsh five finger." The peat varies in depth from 1 to 4 or 6 feet and in places is somewhat mixed with silt. The Columbia River has overflowed this land at various times and in consequence has deposited considerable silt. In many places, however, there is not silt enough in the peat to make the soil available for farming immediately, the soil being a mere mass of fibrous plant residue. As far as he knows there is no peat composed of moss residue in this county. This peat soil is being drained, and attempts are being made to farm it, but these attempts are not very successful. Time is required to bring these soils into profitable cultivation. There is no use made of this deposit for fuel.

Prof. F. W. Rader, of King County, states that there are a large number of valleys in western Washington that contain peat and humus soil ranging in depth from a few feet to 20 feet or more. Many of these valleys are being brought under cultivation, but others on account of lack of drainage are still undeveloped. In a few sections in the Northwest peat is being mined and pressed into bricks and used for fuel. Moss is being gathered in large quantities by nurserymen who use it for packing.

Prof. Charles A. Cole, of Pierce County, states that there are several thousand acres of peat soil in his county in areas varying from five to several hundred acres. The peat is being used for truck gardening and raising cranberries.

AN INTERESTING PEAT BOG IN NEW YORK CITY.

By Roland M. Harper, College Point, N. Y.

What is perhaps the most accessible peat bog in the world—for there are several million people living within 25 miles of it—is located in the western part of Long Island, in the Borough of Queens, New York City, between Maspeth and Middle Village, just east of Juniper Avenue and north of Juniper Swamp Road. It is known locally as Juniper Swamp, though the reason for the name is not evident.

It occupies a glacial basin about 90 feet above sea-level and 100 acres in extent at the ground water level (or several times that at the level where it would overflow), among low hills of bouldery loam, occupied by brush thickets, vacant lots, farms and residences. No streams run into or out of it. Its maximum depth is not known, but may be 15 or 20 feet. Near its northern and eastern edges are two or three areas of open water a fraction of an acre in extent, which may be artificial; but otherwise it is completely filled with peat, on which one can walk safely almost anywhere without sinking in more than two or three inches.

The vegetation is different from that of any other bog known to the writer. Small trees of gray birch (*Betula populifolia*) and red maple (*Acer rubrum*) are scattered over the surface and there are many stumps presumably of the same species where people living near by have doubtless been



Fig. 1. Eastern part of Juniper Swamp showing character of vegetation.
The small trees are mostly *Betula populifolia* and the shrubs mostly
Decodon. Oct. 7, 1916.

cutting them for fuel for many years. About half the present vegetation is composed of the swamp loosetrife (*Decodon verticillatus*; see figure 1), which, although usually classed as a shrub, dies down to the ground every winter so that it has to make a complete new crop of stems and leaves each year. Next in order of abundance among the shrubs are *Clethra*, *Azalea*, *viscosa*, *Cephalanthus*, *Chamaedaphne*, *Leucothoe racemosa* and *Vaccinium corymbosum*. Of these all but *Decodon* and *Cephalanthus* belong in or near the heath family but only *Chamaedaphne* is ever-green.

The principal herbs; in order of abundance, are *Bidens* sp., *Triadenum Virginicum*, *Sagittaria Engelmanniana*, *Dulichium*, *Cuscuta* sp., *Scirpus cyperinus* and *Eleocharis acicularis*. The *Bidens* (beggars-ticks, perhaps two or three species) seems to be confined to the southeast corner, where it grows about five feet tall and covers a few acres very densely, indicating a pretty rich soil, possibly cultivated once, or else fertilized by leachings of manure from adjoining farms in years gone by. The *Triadenum* is the only other herb that is at all abundant. A thin layer of sphagnum is pretty generally distributed over the bog.

This spot is of considerable botanical interest as being the only station within many miles for *Chamaedaphne* and *Sagittaria Engelmanniana*, but it does not seem to have been known to botanists until less than two years ago.*

To produce a new set of leaves for all the trees and most of the shrubs, and a complete new growth of *Decodon* and all the herbs every year requires soil or water much more fertile than that of the average peat bog. The ability of the Juniper Swamp to produce so much vegetation is doubtless explained by the fact that it is surrounded by fertile loamy hills and the underlying soil is so impervious that there can be little loss of fertility by leaching, so that the mineral plant food tends to concentrate as in salt lakes. Peat bogs in sandy regions usually contain many slow-growing evergreen shrubs and trees, which renew only part of their foliage in any one year, and considerable sphagnum, whose annual growth is almost imperceptible.

The peat is reddish brown, pretty thoroughly decomposed a few feet below the surface, and seems to be of excellent quality.

A sample taken Sept. 26, 1917, from near the bottom of the deposit in the railroad cut mentioned below, contained

*There is a preliminary notice of it in *Torreya* (New York), for June, 1917, p. 108.

9 per cent of moisture when air-dried for six weeks. The amount of ash in the absolutely dry material was 7 per cent, a rather low figure;* and a sample from near the surface would doubtless be even better, for that examined evidently contained a little sand, which would not be expected to the upper layers.

It seems from references in Thompson's History of Long Island (1843) that some peat was taken from here in the first half of the 19th century, but as peat has never been very popular in this country the exploitation did not progress very far. The use of the trees for fuel has been noted above. If any juniper (*Chamaecyparis*) ever grew there it must have been all cut out long ago, but there might be evidence of it preserved in the peat. This is one of the few localities in Greater New York where blueberries (*Vaccinium*) can be



Fig. 2. General view of Juniper Swamp from hill on west side, showing partly completed railroad fill and peat squeezed up near the center. Oct. 7, 1916.

found, and that this resource has been utilized more or less is shown by an item in the New York Times for July 16, 1908, stating that a party of berry pickers the day before had found in the Juniper Swamp near Maspeth a human skeleton, supposedly of a man who had gotten mired there.

In 1916 things began to happen to this bog that may soon wipe it off the map. Previous to that time the expense of cut-

*For valuable assistance in making these determinations I am indebted to Mr. Edward N. E. Klein, a botanist and pharmacist of College Point, who furnished all the necessary apparatus and also assisted in selecting the sample in the field. The moisture determination was made with a small drying oven, and the ash determination with a crucible holding about 100 grams of dry material, heated for several hours in a hard coal fire, with frequent stirring, until no more blue flame was given off.

ting a drainage ditch through the surrounding hills, or filling it in, or taking the peat out with a dredge, would have been prohibitive. However, the contractors building a freight connection between the New Haven and Long Island Railroads located their line right across the middle of it, and proceeded to make an embankment of earth taken out of the deep cut just north of it, some time before the middle of the year. This squeezed up the peat on either side to a height of 8 or 10 feet in some places (see fig. 2), showing that it must have considerable depth.

At that time it looked as if the railroad was going to be built on top of the fill and that the remainder of the bog would be undisturbed. (I had not then noticed that the surface of the peat was higher than the land just north of the neighboring cut). But on revisiting the spot last July I found that the grade had been cut down to several feet below the surface of the bog, and instead of an embankment was a cut with its sides acting as dams to hold the peat back; something very unusual in railroad building. Even that would have done little damage, but for the fact that each dam had just been cut through in one place to let the water out, and a stream of typical coffee-colored bog water was running swiftly northward in the unfinished cut. So apparently this unique bog is doomed; and unless some arrangement is made to take the remaining peat out soon it may catch fire and be entirely wasted. There is now afforded an exceptional opportunity for geologists, paleobotanists and ecologists to study the history of the bog, and perhaps make some interesting discoveries.

PEAT IN 1916.

By James S. Turp.*

Utilization of Peat in the United States.

Peat was used in the United States in 1916 mainly for fertilizer and soil builder and as stock food. Small quantities were used for peat litter and fuel, and, as was predicted in the report for 1915, very little peat fuel was produced in this country in 1916.

Peat as Fertilizer and Fertilizer Filler.

The most successful industry based on peat so far attempted in the United States is that of preparing peat for use as a fertilizer or as a filler for chemical fertilizers. Black, thoroughly decomposed peat is most satisfactory for all fer-

*Reprint from U. S. Geo. Sur.

tilizer uses, as such peats are generally heavier and more compact and contain more nitrogen and less fibrous material than the brown types.

There was an increase of 26 per cent in the production of peat used for fertilizer in 1916 over the output in 1915. Part of the increase is accounted for by the use of peat in the cultivation of lawns, and it is expected that this use will still further increase. Owing to the intensive cultivation of crops in parts of this country, it would seem that now is the time for peat operators to make better known the importance of peat for agricultural purposes and thus aid in relieving the shortage of other fertilizer materials.

The production of peat for fertilizer and fertilizer filler during 1916, as reported, was 48,106 short tons, valued at \$336,004, compared with 38,304 short tons, valued at \$258,447, in 1915. The selling prices given varied widely according to the grade of the product, the uses to which it was to be put, and the quantity and quality of the materials added. The lowest price per ton reported was \$3, the highest \$22, and the average about \$7.

The following table shows that in only one year, 1911, since these figures were first published by the Geological Survey, has the quantity of peat for fertilizer been greater than in 1916. The value of peat produced for fertilizer was greater in 1916 than in any other year.

Peat used for fertilizer produced in 1908-1916.

Year	Quantity (short tons)	Value	Year	Quantity (short tons)	Value
1908.....	23,000	*\$121,210	1913.....	28,460	\$169,600
1909.....	26,768	118,891	1914.....	37,729	249,899
1910.....	37,024	140,209	1915.....	38,304	258,447
1911.....	51,733	257,204	1916.....	48,106	336,004
1912.....	41,080	186,022			

*Estimated.

Stock Food.

Two firms reported the production of peat for stock food, the total amounting to 4,300 short tons, valued at \$32,250, at an average price per ton of \$7.50.

The quantity showed an increase of 320 tons over that of 1915, in spite of the fact that production in 1916 was reported curtailed because manufacturers were unable to secure molasses, munition manufacturers having taken the supply of molasses at a price that manufacturers of stock food could not afford to pay. It is stated that this peat is used to overcome the bad effects, such as bloating, of molasses on the digestive organs of stock and that it practically takes the place of charcoal.

Peat Litter.

No peat litter has been produced in the United States for several years. As in previous years, however, a certain quantity was imported in 1916 under the name "peat moss." The entire importation was 3,042 short tons, valued at \$27,859, or 9.16 a ton, an increase in value per ton over 1915 of \$2.75, but a decrease in total quantity of 4,472 tons and in total value of \$20,283. The imports of "peat moss" have been steadily declining for several years.

Production.

During 1916, as in 1915, no new processes or machinery for preparing peat were reported to have been commercially tried in the United States, but several firms reported additions and improvements to their plants. The total number of firms reporting production in 1916 was 13, all but one of which sold peat for fertilizer. Two also sold peat for stock food. One sold a small quantity of peat for fuel. The nine firms that furnished data for 1915 furnished data also for 1916, and four firms reported that were not represented in 1915.

The plants known to be at work during the year were distributed as follows: Maine, 1; Massachusetts, 1; New York, 2; New Jersey, 4; Pennsylvania, 1; Florida, 1; Indiana, 1; Illinois, 2.

The quantity of peat products made and used in the United States in 1915 and 1916, so far as these have been reported, are given below:

Peat produced, imported, and consumed in the United States in 1915 and 1916.

Use	Production		Imports		Consumption	
	Quantity (short tons)	Value	Quantity (short tons)	Value	Quantity (short tons)	Value
1915—						
Fertilizer and fertilizer filler	38,304	\$258,447	.....	.....	38,304	\$258,474
Stock food	3,980	30,090	.....	.....	3,980	30,090
Peat moss litter .....	.....	.....	7,514	\$48,142	7,514	48,142
	42,284	\$288,537	7,514	\$48,142	49,798	\$336,679
1916—						
Fertilizer and fertilizer filler	48,106	\$336,004	.....	.....	48,106	\$336,004
Stock food	4,300	32,250	.....	.....	4,300	32,250
Miscellaneous	100	850	.....	.....	100	850
Peat moss litter .....	.....	.....	3,042	\$27,859	3,042	27,859
	52,506	\$369,104	3,042	\$27,859	55,548	\$396,963

Peat Industry an Accessory

By Alfred C. Lane

More than ten years ago I interested C. A. Davis in peat as a subject he was especially well qualified to handle. I have followed his work to its close, which we all so much regret. I have been a member of the Peat Society from the beginning, knew Mr. Kleinstuck, another of the departed members, and have seen something of what has been done in Michigan, Canada, and Massachusetts, and the question has naturally occurred to me, Why has so little of real commercial success been obtained? Here is a raw material that exists in large quantities. The finished products, whether the "Boston humus" of Lexington, or the filling for tankage and base for fertilizer, or peat briquets, have always had a ready market, and I have never heard of a plant that failed because of a great accumulation of finished product on its hands.

And yet on the whole almost the only money that has been made has been by those who manufacture machinery, and possibly by some who have exploited the stock-certificate-buying public rather than the bogs.

I think the answer is that the peat industry is essentially a seasonal one, which should be prosecuted only a part of each year, and that often at a time when the products are least needed. Therefore the force must find something else to do for a good part of the time, and the overhead charges and the interest on the capital required for carrying the matter must be expected to constitute a large part of the cost, for which not enough has been allowed.

Take for instance the following statements made to me in an endeavor to sell me some years ago some stock in an enterprise to develop one of the most promising peat deposits in the country. The figures would not apply now:

Peat as Fuel, with 14 Per Cent H₂O.

Selling price	\$6.00
Cost of selling .....	.25
Net receipts per ton	\$5.75
Costs:	
Digging and draining	\$.60
Drying	1.00
Loading10
	<hr/>
	\$1.70

Overhead charges: Superintendent, etc.	1;13	\$2.83
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Net profit, per ton	\$2.92
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Daily profit, 30 tons per day	\$ 87.60
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Yearly profit (300 days)	26,280.00
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Working double shift	53,560.00
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I need not say that no such results were attained. Now where was the biggest error? Not, in this particular case, in the possible receipts per ton; as a matter of fact better prices could be obtained then than now. Not, at that time, in the detailed cost when running. The cost figures were based on the assumption that the plant would be run 300 days in the year. I doubt whether this plant was ever run over 75 days in a year. Unless there is some other occupation, then, to which we can charge the costs of labor and superintendence, working even half the time will nearly double the costs, and presto! profits vanish.

But why cannot we run a plant all the year? The raw material as it is in the bog is 90 per cent water, or more, which will hardly drain below 80 per cent. This water is of no use and must be largely eliminated, with little expense, or the cost of moving and handling the water will consume all possible profits. Now we cannot work on a bog any more than on a farm on very rainy days or when the bog is covered with snow. Therefore those days must be cut out anyway. Moreover, to handle peat with 70 to 80 per cent moisture and to dry it by artificial heat, and still make anything, is impossible, when we consider that it is theoretically possible to evaporate only 14 or 15 pounds of water with a pound of coal, and ordinarily six or eight is what is obtained in a boiler, unless a peat bog happens to be near some big plant where there is a lot of wasted heat. But if we expose the peat to the heat of the sun and dry air, the water may be easily evaporated down to 50 per cent. The upper six inches of a bog may indeed vary from 15 to 20 per cent of moisture, according to tests by E. L. Claff, one of the Tufts College students.

Peat, like soft coal, absorbs moisture from the air, and if dried below 15 per cent moisture will rapidly absorb it again from the air even when under cover. The problem, then, is to take the peat from the upper layers of the bog only (too deep draining also brings serious risk of fire), and to expose it to sun and air to evaporate as much of the water as possible before employing any further treatment. This can be effectively done only at limited periods, as peat accumu-

lations are, with rare exceptions, in damp climates—those in which moss readily grows.

A subject for investigation by the Peat Society is the climatology of peat, the number of days of good peat-drying weather that may be expected, the ratio of rainfall to evaporation to make peat getting a success, and the depth to which it will pay to handle the peat the different circumstances.

Then the material once procured must be stored until needed. As regards peat fertilizer, this period is spring. As regards fuel, this period is winter, for only rarely will peat be used as a steam fuel, yet its cleanliness, fragrant odor, and easily handled ash, commend it for domestic use. For other uses, such as for disinfectant, peat products are not so dependent on the season. However, as a rule, storage for nine months or so must be counted as part of the probable cost, for the time of peat harvest must be the hot summer months. The labor used must have some other occupation for the rest of the year. Student vacation labor might be used to some extent, but the superintendents and the skilled workers must have something else to occupy them. What shall it be?

PEAT IN CUMBERLAND COUNTY, MAINE.

The growth and decay of water-loving vegetation flourishing in certain poorly drained areas gradually forms accumulations of more or less decomposed organic matter, which when quite thoroughly decomposed and mixed with a small proportion of mineral matter is classed as muck, but when only partly decomposed and practically free from mineral matter is known as peat. On account of intricate association of the two and their small total extent in the county, they are mapped together.

Muck consists of a dark brown to black, smooth, finely divided and thoroughly decomposed mass of organic matter with an admixture of mineral matter consisting of silt, clay and fine sand. The fine sand occurs mainly in marginal and other shallow areas. The depth of the organic deposits ranges from 18 inches to 3 feet or more. To a depth of 18 to 24 inches the material is fairly uniform in texture, color and structure. Mucky material of greater depth has a slightly more fibrous texture and a dark brown color. The typical muck is usually sticky to somewhat plastic when wet.

The separation of muck from tidal marsh in the section south and southeast of Portland is based mainly upon the presence of a growth of small trees on the former. One type

grades into the other so gradually that no definite boundary can be based upon texture and structure of material. These areas which lie just beyond the tidal marsh have doubtless been influenced to some extent by salt water and salt-water vegetation.

The underlying material varies with the position in which the type has been developed. On sandy terraces and along streams it is either a gray sand or sandy loam. Within acres of glacial till it consists of compact deposits of ice-laid material of clay or of bedrock. As a rule, the more shallow areas are found on the terraces. Depths of 25 feet are reported for some of the bogs. The depth of the organic accumulations around Great Pond, in Cape Elizabeth Town, varies from 3 to 13 feet.* The depth in an area one-half mile east of Highland Lake (Duck Pond) is said to be from 17 to 18 feet. The deposit in Rigby Bog, south of Portland, varies in depth from 1 to 2 feet.

Peat is a brown, fibrous mass of partly decayed vegetation, with admixture of very little mineral matter. In depth it varies from 1 or 2 feet to more than 15 feet. The sandy material of the terraces or the glacial till of the uplands underlies the organic accumulation.

One area along Merrymeeting Bay, about 5 miles northeast of Brunswick, might be classed as a salt-water variation of peat. It conforms to the general description of the type, but occurs on a tidal flat, and is at times covered by rather brackish water. It lies practically at the mouth of the Androscoggin River.

Muck and peat have a fairly wide distribution over the county. Areas from 10 to 250 acres or more in extent are found within the limits of all the soil series in the county except Orono and Podunk. They lie along streams, around ponds, and in broad depressions, where the wet conditions have been favorable for the growth and decay of vegetation and the accumulation of the resulting products. Among the largest of the areas of muck are the Rigby Bog southeast of Portland; the area around Great Pond, in Cape Elizabeth Town; areas along Dunstan River, in Scarboro Town; along North West River, in Sebago Town; and others near Richville, in Standish Town, west of Bridgton village, and a few miles south of Harrison village. Numerous areas too small to show on the soil map are included with the surrounding types.

Several acres of a distinctly peaty character, ranging from a few acres to 200 acres or more in extent, occur in different

*The Peat Deposits of Maine," U. S. Geol. Survey, Bull. 376.

sections of the county. Of these the principal areas are found one-half mile east of Highland Lake (Duck Pond), north of the city of Westbrook, 2 miles southeast of Bridgton village, at the south end of Rigby Bog, southeast of Portland, and the one already mentioned northeast of Brunswick.

The surface of the areas of muck and peat is practically flat. Along streams it has a slight slope in the direction of stream flow. In elevation the areas range from 15 to 500 feet or more above sea level. The streams crossing areas of these two soils have a very sluggish current and a meandering course. Ponds and sloughs occur in places. Water frequently stands on the surface for long periods, and the material is in a saturated condition during the greater part of the year.

Only a few acres of muck, situated along the Dunstan River in Scarboro Town, are in cultivation. This tract is used in certain seasons for oats. In other seasons crops of hay are cut. The yields are fairly good in favorable seasons.

Peat and muck are rarely sold alone, and the sale value is difficult to fix. It could doubtless be purchased for \$5 an acre.

The drainage of much of the muck is possible and practicable. When well drained it is adapted to the production of onions, celery, lettuce, cabbage, and other truck crops. With proper management and good marketing and shipping facilities, these crops can be made to give big returns on the investment for the land and its preparation for farming. Cranberries should prove a profitable crop where the bogs may be flooded easily.

None of the peat is under cultivation. When cleared and drained it could be used for hay. The returns from this source would probably not justify the expense of preparation. It is not well adapted to cultivated crops, even when drained. Cranberries would be successful on those bogs which can be easily flooded.

Investigations have been made by private parties and by the United States Geological Survey* to determine the character, extent, and value of these deposits for fuel. Peat may be used as a source of organic matter for soils that are low in that constituent. It may also be used as an absorbent in stables.

Peat Deposits in Fairfax and Alexandria Counties, Va.
Tidal Marsh consists of a bluish or bluish-gray to black silt loam to silty clay, faintly mottled with brown or yellow,

"The Peat Deposits of Maine," U. S. Geol. Sur. Bull. 376.

and several feet deep. The greater part of the soil mass is composed of fine grass roots in various stages of decomposition.

Tidal Marsh is not extensively developed. It occurs in small areas at the mouths of tributaries of the Potomac River and in the estuaries of the river. The largest area lies about 2 miles south of Alexandria.

The surface of Tidal Marsh is perfectly flat and lies below the water level at high tide. It is nearly always covered with water, which varies from a few inches to 2 feet in depth. Small lagoons and channels of open water wind through the marsh areas.

The native vegetation consists of a heavy growth of wild rice, marsh grass, flags and other water-loving grasses and plants.

In its present condition Tidal Marsh has no agricultural value. If reclaimed it would probably be well suited to celery and onions, but it is doubtful whether such small areas could be profitably reclaimed.

Peat Deposits in Schoarie County, N. Y. The surface soil of the muck consists of an accumulation of dark-brown to black decomposed vegetable matter mixed with fine particles of soil washed from higher lying areas. It varies in depth from 12 inches to several feet. The subsoil under most of the muck is a blue or mottled gray and drab plastic sandy clay.

The largest areas of muck are encountered in the towns of Sharon and Carlisle; smaller areas are widely scattered throughout the uplands. All the areas occupy low-lying positions and are naturally poorly drained. Most of this type supports a growth of cedar, hemlock, and elm, as well as water-loving plants and bushes. None of it is under cultivation. A few of the larger areas might be reclaimed by drainage. Values are based on the quantity and quality of the standing timber, the larger tracts usually bringing about \$10 an acre.

Peat Deposits in Clinton County, Iowa. Muck, as mapped in Clinton County, is of two kinds, deep and shallow. On account of their small total area, low agricultural value, and intricate association, these are not separated on the soil map. The shallow deposit predominates. It consists of 6 to 18 inches of a black, finely divided, well decomposed muck, some of which is rather silty, grading into a subsoil of black or dark drab to drab silty clay loam or silty clay. The subsoil is heavy, stiff, compact, and impervious, is sometimes mottled with rusty brown, and frequently contains iron concretions. In

places there occurs between the typical soil and subsoil a layer of dark-brown to black nonfibrous peat, generally not more than 4 to 8 inches thick. At the edges of the areas of muck soil material from the surrounding higher lands has been mixed with the surface material.

The muck where deep consists of 8 to 15 inches or more of black, finely divided, well-decomposed organic matter, which grades into a black to dark-brown non-fibrous peat. This may continue throughout the 3-foot section or it may be displaced in the lower part of the section by a dark-brown to brown, semi-fibrous and in some places fibrous peat. The heavy clay material underlying the shallow deposits does not usually occur within 36 inches of the surface. The deep areas are generally encountered in the center of the larger areas mapped as muck. The muck includes small areas of black, non-fibrous peat, which has the appearance of muck and is well decomposed, but lacks sufficient inorganic matter to be classed as muck. Some small areas of typical peat, generally more than 3 feet in depth, also are included.

The muck areas occur mainly in the belt of drift material. Muck is the result of accumulation of organic matter in ponds and depressions and along drainage ways. It occurs also in the bottoms of old lakes which existed in the Goose Lake channel west of Goose Lake prior to the installation of the drainage ditches that removed the greater part of the water. The largest areas are near Calamus and Lost Nation; smaller areas occur at the heads of and adjacent to the minor drainage ways of the county. The largest area of the deep deposits is in the bed of the larger lake west of the village of Goose Lake.

During the rainy season the muck generally is wet and boggy, and because of its situation and the impervious character of the underlying clay it is poorly drained throughout the year. In some areas fairly good drainage has been established through tiling or ditching, and corn is produced successfully. Crops are subject to damage by the early light frosts. The native vegetation consists mainly of marsh grass, smartweed, and other aquatic plants. Yields of about 1 ton per acre of a fair quality of wild hay are obtained in places.

PEAT AS A COAL SUBSTITUTE.

Among the various suggestions that have been made from time to time with a view to trying to find a suitable substitute for coal, the feasibility of using peat has been

raised on many occasions, but hitherto, both for commercial and mechanical reasons, its practical utilization has failed. Probably one reason for failure is that it is not generally known how to convert the raw peat into a hard and densified fuel that will not crumble in burning. Peat fuel suitable for commercial purposes has not been produced hitherto without the use of a complicated but expensive plant, to employ which for making the fuel in large quantities would neither be practical nor pay commercially. Nevertheless, inventors continue to pursue the old idea of using pressure to squeeze out the water, ignoring the fact that the use of pressure in any form will never produce from peat a fuel in such a hard and dense condition as will enable it to compete successfully with coal.

In an interesting process invented by Sir Edward Zohrab, Bt., this difficulty appears to have been overcome; not only is pressure not used, but no expensive machinery is required. The process may be briefly described as follows:

The raw peat, when taken from the bog, is placed in a mill, which not only pulps and molds it into blocks or briquets of any desired size or shape, but so thoroughly and effectually desiccates the fuel that all the fibers or tubes which permeate the peat and are filled with water are completely cut to pieces. These fibers or tubes, if not perfectly destroyed, continue to hold water, which is converted into steam in the drying process, thus preventing the peat from becoming a perfectly homogeneous and dense fuel. No compression whatever is used, and to attempt to produce a satisfactory peat fuel by pressure would appear to be foredoomed to failure, since no matter how much the peat is pressed, the fibers, if not completely broken down, resume their natural size as soon as the pressure is withdrawn, again filling with the moisture remaining in the peat, thus causing the blocks to crack and crumble.

From these special mills the blocks of peat are conveyed on travelling bands to the drying machine, from which in a few hours it emerges in a very hard and densified form, containing, according to a typical analysis, only 15.5 per cent of moisture, and having a specific gravity of 1.29. It would seem that in this form peat should possess a future as a coal substitute, provided that the selling price was right.

Apart from the use of densified peat as an ordinary fuel in circumstances where coal is now consumed, it is when the peat is converted into charcoal—or perhaps we should term it peat-coke, judging from an analysis which shows figures closely resembling but somewhat better than those for good

quality Durham coke—that its uses should be most extensive. In the iron and steel industries there are obvious possibilities. It is claimed that it can be successfully used, not only to produce charcoal iron, but also in the blast furnace on account of its hard, homogeneous character, thus enabling it to stand the burden of ore which would cause ordinary peat fuel to crumble to powder.

As a fuel for locomotives densified peat has been tried with success. The first test was on a goods train weighing 145 tons, the locomotive weight being 56 tons. The fuel placed in the tender was a mixture of densified peat and Scotch coal in the proportion of 9 cwt. to 3 cwt. The length of the test run was 38 miles, part of the distance being up a heavy grade. The amount of fuel used was 10 cwt., 1 qr., 6 lbs., equal to 30.4 lbs. per mile. The second test was made on an express train running between Glasgow and Dundee and back, a distance of 180 miles. The fuel was one-third Scotch coal of a poor quality and two-thirds densified peat. The fuel consumption was at the rate of 31.4 lbs. per mile. The average consumption of coal on the railways on which the trials were made was 44 lbs. per mile.

Each ton of the densified peat produces 8 cwt. of charcoal, as well as large quantities of valuable by-products, including sulphate of ammonia, alcohol, acetic acid, phenols and oils. Besides these, large quantities of gas are evolved, this being a mixture containing about 10 per cent hydrogen, 11.5 per cent methane, 3.4 per cent ethylene, 14.4 per cent carbon dioxide. The amount of gas given off from one ton of densified peat is stated to be 14,000 cubic feet. Some of the gas thus produced is employed in connection with the drying machines, and is used as part of the blast in the iron furnaces, thereby augmenting the heat and economizing the solid fuel required.

It would certainly seem, in view of these claims, that the time is ripe for another attempt to be made to use successfully the vast deposits of peat contained in these islands. If this could be done, then we should have another source from which to obtain our light, heat, and power; mineral deposits now undeveloped in consequence of the coal being too far distant to enable them to be worked could be utilized; a high grade of iron could be produced from our own ores; we should have a smokeless fuel, and lastly, our coal deposits would be conserved to a very considerable extent.—London Daily Telegraph.

PEAT DISTILLATION.

Although it is generally recognized that the great natural stores of peat in this and other countries are capable of yielding numerous valuable products, the cost of extracting those products from wet or semi-dried peat has over and over again been found to swallow up all the profits of the operation. But the problem continues to engage the attention of inventors, and in the present article an account is given of an apparatus which represents many years of original investigation and has only recently been brought to the stage of practical test. The inventor's aim has been to produce a compact plant which can be erected on the peat bog and which is simple, continuous in action, and economical.

Raw peat, even if well drained before it is cut, contains up to 90 per cent of water, and parts with its moisture with extreme reluctance. It has been found that, in order the more readily to expel the water, it is necessary to break up the cellular structure of the mass, and this can best be accomplished by a process of maceration.

Removal of Moisture.

After undergoing a simple system of mechanical treatment, and the formation of briquets, the peat can be dried in a current of hot air, so as to contain as little as 20 to 25 per cent of its weight of water. The drying of the macerated peat takes place in the present plant in a horizontal chamber placed above the retorts. The contents are kept in motion by a scraper or conveyor, by which means the briquets are turned over and over and travel slowly forward through the hot gases that are on their way to the flue. All parts of the macerated peat are thus exposed in turn to the current of heated air, and at length reach the inlet, placed above the cool end of the retort. The dried peat is fed on automatically through an air-tight valve of special construction. The retorts are set horizontally in pairs and consist of iron tubes some 24 feet in length by 18 inches in diameter. A screw conveyor passes through the center of the tube, with a clearance of $\frac{3}{8}$ inch all around, and is driven at a very slow rate. The charge takes about 45 to 50 minutes to travel through the retort, and as it passes forward towards the firing end the temperature gradually rises till the hot zone is reached.

At the start of the operation heat is supplied by means of producer gas, generated from a small auxiliary apparatus, working with air-dried peat; but, after an hour or so, the gas evolved from the peat undergoing treatment is found to be sufficient for all purposes. This is pumped out of the scrubbers and introduced in the form of jets, impinging against the outer surface of the retort, the air needed to maintain com-

bustion being blown in by a small fan. The jets are arranged in pairs at the hot end of the retorts. As soon as the temperature of the retort approaches 100° C., the peat begins to part with its moisture, and the vapor is drawn off at the upper part of the tube, passing into a condenser of special construction, which takes the form of a series of shallow inverted cones. The hot vapors encounter at the top of the condensers, which are placed on either side of the retorts, a current of cooled gas, acting somewhat on the principle of the injector, and before reaching the scrubber they are deprived of all watery particles, so that only the noncondensable gases are carried forward.

Extraction of Oils.

At the hot end of the retort, where the internal temperature may vary from 400° to 450° C., the oils given off from the charge are drawn into a separate set of condensers, also placed on either side of the retorts, and the noncondensable vapors are cooled by being passed through scrubbers, for use as fuel gas.

It is important to note that the volatile constituents of the peat are drawn off from different parts of the retort immediately they are formed, and are condensed and separated from the gaseous, noncondensable portions in apparatus of a novel and special type, so that the oil contents are withdrawn before they have time to become deteriorated by undue exposure to heat. Moreover, the gas, freed from oil, which results from the carbonization, suffices, so soon as full heat is reached, to carry on the treatment of subsequent charges and thus the distillation process is rendered continuous and self-supporting. It is found that macerating and briquetting the peat, as also for driving the conveyors, fans and pumps, in the case of a 10-ton unit, 10 horsepower suffices for all purposes, or say, 1 horsepower per ton of peat treated.

The yield of oil, which of course varies with the nature of the peat under treatment, amounts to 25 to 30 gallons per ton of dry peat. A definite trial extending over a considerable period gave 26.5 gallons per ton. On distillation of the oil residues the following results were obtained:

Water	6.00
Oil distilling below 100° C.	1.25
Oil distilling from 150° to 250° C.	27.40
Oil distilling from 250° to 360° C.	48.30
Residual pitch	15.70
Loss	3.50
	100.00

On refractionation of the two fractions 150° to 250° C., and 250° to 360° C., fuel oil answering to the Admiralty specification can be produced, and after taking off the oil there is a residue of paraffin wax. In the above run the equivalent of 18 pounds of ammonium sulphate was also obtained per ton of peat.

After extraction of the oily matters and tar, the charcoal withdrawn from the extreme end of the retort by an automatic process was found to range from 30 per cent to 33 per cent of the weight of the raw peat. It contained 11.82 per cent of volatile matter, 79.71 per cent of fixed carbon, and 8.47 per cent of ash, though it varies in character in accordance with the density of the peat in the briquet form, and with the length of time the charge remains in the retort. The amount of volatile matter can be raised in accordance with the character of the retort treatment.

In working up the water solution from this process the yields per ton of peat treated were found to be as follows:

Wood spirit, gallons	2.56
Acetic acid, pounds	19.1
(As calcium acetate), pounds	23.8
Ammonium sulfate, pounds	8.0

There is also a quantity of tar, varying from 4 to 10 gallons per ton of peat.—From Eng. Suppl. of London Times.)

Peat in Bremer County, Iowa. (Soil Survey of Iowa, Report 1, by W. H. Stevenson, P. E. Brown, and F. B. Howe.) Only three small areas of this material are mapped in Bremer County, but there are several small areas which are too small to be shown. The entire acreage in the county, however, is extremely small. This material is composed mainly of partly decomposed vegetable matter accumulated in poorly drained areas. It is black or dark brown in color, and in texture it is loose and friable when dry but spongy when wet. Small amounts of mineral matter are always present, mainly silt and clay washed in from the surrounding soil. The subsoil is usually a clay loam or a clay, but occasionally pockets of sand are found. The drainage of these areas is the first essential for cultivation and when this is accomplished, the soil may gradually be brought under cultivation.

Coke from Peat. The Peat, Coal and Oil Syndicate of Doncaster, Yorkshire, is developing a new method for treating a special variety of dry black peat and converting it into a hard foundry coke, the by-products being tar and tarry liquids from which automobile oil can be obtained by distillation. It is not claimed that all varieties of peat can be

profitably used, but it is said that hundreds of acres containing millions of tons of peat can be commercially utilized by this process.

The black layer at the bottom of the bog is most suitable for the manufacture of coke. This material is freed of its excess of water and subjected to a carbonizing process by means of which by-products are recovered, the residue being a soft friable coke. Notwithstanding that peat coke has lower sulphur content than any other combustible, up to this time its insufficient hardness has been an obstacle to its application in blast-furnace operation. This fault, it is claimed, is now overcome, and a hard, strong and pure coke is now obtained. A German chemist has proved by analysis that 1,000 tons of air-dried peat will produce 400 tons of coke, 40 tons of tar, and 400 tons of tarry liquids. The tar can be further distilled to yield 18 tons of crude oil, 2 tons of creosote, 2 tons of pitch, and 8 tons of paraffin. The tarry liquids will yield 4 tons of sulphate of ammonium, 6 tons of acetate of lime, 2 tons methyl alcohol. It is estimated that there will be a profit of 90 c. (centimes) on every ton of peat so treated.—Journal of the Franklin Inst., vol. 184, 1917, p. 442.)

Irish Peat Utilization. According to the "Electrical Review," among various suggestions recently advanced for Irish industrial development, one that has received much attention is the utilization of the vast peat bogs of the country for electrical purposes. At the annual congress in Dublin, recently, of the Irish Technical Association, Dr. J. H. Grindley read a paper on the peat resources, entering a strong plea that the Government and the newly established Research Council should have impressed upon them the urgent need for assisting in this direction by research work on the basis of nationalization; and Dr. J. F. Crowley submitted a paper dealing with the cheap distribution of power. Sir Thos. W. Russell, Bart, vice president of the Technical Agricultural Department, said that the peat question had got into the worst possible hands and warned the congress that if scientists were going to deal with it, they should remember that they could not take the peat bogs out of the hands of the peasants, to whom they were a necessity, without considerable trouble. The president (Sir Bertram Windle) said that one of the misfortunes of Ireland was that the people never really got a grip of the value of research. A leading authority on electricity has written to the Dublin Press in protest against Sir Thomas Russell's attitude as closing the door to investigation. He points out that there are in Ire-

land 3,000,000 acres of fuel bog—a supply that would last for 1,000 years—and urges that if science could utilize these deposits it would not fail to provide a less primitive method of supplying the heat requirements of the peasant, who would readily understand that any great development of the country on commercial lines would develop him as well.—Through Indian Engineering.

Peat-Fuel Manufacture in France. In the British House of Commons on Monday, August 20, Mr. Rowlands asked the Under-Secretary of War whether the steps taken by the War Department in connection with the peat-fuel factory to be erected in France have been such as to insure that the best and most economical method of treating peat with a view to its economic dehydration has been selected; whether the general knowledge available as to the workability or failure to work particular processes has been given due consideration; whether the official literature on this point published by the Canadian Bureau of Mines, the Bureau of Mines of the United States, the records of the Swedish Government, and other analogous data, have been given due weight, and, if departed from, for what reasons; whether the reports of the Admiralty on peat proposition have been taken into consideration and acted upon by the War Department; whether reliable assurances have been forthcoming that peat fuel will be produced during this winter from the factory intended to be erected for supply to the trenches; and, if not, the earliest date on which such supply will be given.

Mr. Macpherson replied in the affirmative. The War Department consulted the Ministry of Munitions and received a satisfactory report. No reports have been received from the Admiralty on the matter. As regards the last part of the question, no assurances have been or can be made. The date of delivery of supply depends upon many factors, such as the supply of machinery, material and labor, which under present conditions it is impossible to estimate with any certainty. Every endeavor is being made to obtain a supply at the earliest possible date, but it is very doubtful whether the factory can be in operation during the coming winter.

Peat Containing Water for Use as Fuel. (G. Merkel, U. S. Patent 1,229,637). Solid fuel is prepared from wet peat or similar material by first exposing it to the air until the H₂O content has been reduced to 50 to 55 per cent, then treating it with a current of moist air at a temperature somewhat below 100°, and finally distilling.

Peat Fuel for Gas Producer. (T. Rigby, U. S. Patent 1,233,606). Peat press cakes containing about 68 per cent

H_2O and peat briquets containing only about 5 per cent H_2O are supplied from separate sources and mingled in regulated amounts as a fuel for gas producers. It is thus adjusted to contain a uniform and predetermined amount of H_2O throughout its mass.

Peat as Producing Material in Smelting Ores. (N. Testrup and T. Rigby, U. S. Patent 1,233,144). Peat is heated to 180° under sufficient pressure to prevent ebullition, freed from liberated H_2O by filter pressing and then molded into blocks which are mixed with a charge of ore to be smelted and heated by the waste heat of the smelting operation before they reach the smelting zone so that they are prepared to serve as a reducing agent for effecting smelting of the ore.

Microorganism of Peat Soils. (T. Arnd, Central Bakt., 1916, vol. 45, p. 554.) Preliminary trials at the Bremen Experiment Station to ascertain the effect of drainage, liming and tillage on the bacterial life of peat soils, gave the following general results. Ammonifying organisms were present in all samples, but were far more active in surface soils than in subsoils, and in cultivated than waste land. The breaking up of waste land affected the bacterial life only to a depth of about 8 inches of soil. No nitrifying organisms were found in waste land or cultivated land, except such as received a dressing of more than $\frac{1}{2}$ ton of lime per acre; more than 1 ton per acre would appear to be necessary to produce active development of the nitrifying organisms in the peat itself. All the samples tested were able to reduce nitrates; the surface soil of waste land was not much more active than the subsoil, but the surface soil of cultivated land showed much more activity, especially where tillage had been accompanied by liming. Similar relations were observed in respect to the power of decomposing cellulose. As with ammonification and nitrification, the maximum decomposition of cellulose occurred when the soil had previously received a dressing of dung. In no sample of soil was Azotobacter present. Surface soils and cultivated soils fermented mannitol more readily than subsoils and waste land, the maximum effect again being obtained with a dunned plot.

NEW PEAT COMPANY.

The Fertile Chemical Co. of Cleveland, Ohio, has been organized and will build a plant to develop the peat beds in Sturgeon Swamp, Cooper County, Mich. C. F. Hancock will be local manager of the company. The Atlas Engineering

Co. of Cleveland has the contract for the construction of the plant and equipment.

Mr. C. F. Hancock has recently been enrolled as a member of our Society.

PEAT BRIQUET FACTORY IN DENMARK.

In Denmark a peat briquet factory is in course of construction close to Bronderslev, where an attempt was made some years ago with English capital to start the manufacture of ammonia and briquets. The peat briquet is of similar shape to the lignite briquet, but the substance is much harder, almost like glass. The number of British thermal units is 8,100 against between 3,500 to 6,300 for ordinary peat. The briquets are made from natural peat containing some 90 per cent of water, of which the bulk is removed by a preliminary process, so that the peat is reduced by pressure to about one-quarter the original weight. The peat substance is then subjected to a similar process as that used in the lignite-briquet manufacture, a pressure of 1,200 to 1,500 atmospheres being used, the bituminous substances of the peat serving as cementing medium. The new factory will commence with 1,200 acres of bog, with the option of taking over the remaining part of the English lease, which altogether in this district comprises 4,300 acres of the Store Vildmore deposits. There will be two compressors, each with engines of 210 horsepower. The price had been fixed at \$6.67 per ton on the spot. It is anticipated that at this price the whole share capital of \$217,800 will be written off in the course of three years.

PEAT FUEL IN FRANCE.

In the British House of Commons on Monday, Aug. 13 last, Mr. Rowlands asked the Under-Secretary of State for War whether any action had been taken by the Government, and, if so, the nature and extent of such action, with regard to the utilization of the French peat deposits so as to relieve the coal supply from England in respect of fuel to the armies in France.

Mr. Macpherson replied that this matter had been the subject of close investigation for some time by the War Department, and that arrangements had been made for the erection of a peat-fuel factory in France to help to supply the Army in France with trench and other fuel in substitution for charcoal, coke and coal, and to that extent to relieve the coal supply from England.

Peat Treatment for Fertilizers. (A. Nightingale, Br. Pat. 108543, 1916.) Peat for agricultural and horticultural purposes is treated with calcium oxide in order to neutralize the organic acids and to produce certain products that stimulate bacterial activity and plant development. The raw peat as dug or ground or in a dusty condition and containing 50 to 70 per cent by weight of moisture is thoroughly and rapidly mixed with one-fifth by weight of calcium oxide so that the temperature rises to 220° F.

Brazilian Peat. The principal seams of peat are those of the River Marahu, in the State of Bahia, the seams being 15 m. thick. By a simple process of distillation, the peat of Marahu is capable of yielding nearly 400 kilos of combustible oil per ton, which gives it a great industrial value. It is composed of the following elements: Volatile hydrocarbons, 72 per cent; fixed carbon, 10-5; and ash, 17-5.—Colliery Guardian.

Electricity from Irish Peat. According to the "Electrical Review" it is announced that Mr. Keating, M. P., Secretary of the Industries Committee of the Irish Parliamentary Party, has received an assurance from the Prime Minister that the representation as to adding to the Irish Committee on Peat a member with electrical experience will receive attention. The name suggested is that of Dr. J. F. Crowley, the Irish representative on the Board of Trade Committee which is investigating the sources of electrical power in the United Kingdom. It is claimed for him that he is possibly the only Irishman who has had extended practical experience of research on a large scale in relation to electrical engineering. An experiment in the production of electricity from peat is now being made, and it is held by expert authorities that in that direction mainly lies the best and most serviceable use of the vast reserve of peat stored in the Irish bogs.—Indian Engineering.

Peat Alcohol. The British Government has decided to investigate the possibilities of Irish peat as a fuel. Peat is one of the many available sources of alcohol. Most motor car engines can be run on a half-and-half mixture of alcohol and benzol, and both of the spirits comprising this mixture are produced in the United Kingdom, the former in unlimited quantities, since it is a vegetable product, and the latter to the extent of about 100,000,000 gallons per annum (after the war.) This means that the country ought to be able to

produce 200,000,000 gallons annually of an alcohol-benzol motor fuel, or nearly twice the amount of gasoline that was being imported annually before the war.—Consular Report.

Economic Utilization of Peat from Chateauneuf-sur-Rance, France. (C. Galaine, C. Lenormand and C. Houlbert, Compt. rend., vol. 165, 1917, p. 337.) Ekenberg has shown that peat heated under pressure to a temperature above 150°C. loses its gelatinous consistency and can then be easily dried by compression. The process has not yet been applied industrially, but the product possesses very striking properties, being no longer peat, and for convenience the authorities have given it the name "tourbon." The calorific value of "tourbon" is 10 per cent higher than that of dried peat, and is about 6,500 kilo-cal. The hydro-cellulose being destroyed in passing through the autoclave, "tourbon" does not absorb moisture after drying. "Tourbon" is particularly rich in volatile matter, one sample of anhydrous "tourbon" showing 61.3 per cent. The authors first reduce the water content of the peat in a continuous press (Mabille. Anrep system, etc.) at a pressure of 50 to 100 kilos per sq. cm. (700 to 1400 pounds per square inch, bringing the water content of the briquets produced down to 60 per cent. The briquets are placed in layers in carriages and heated for 25 minutes in horizontal autoclaves by steam at 160°C. Freed from gelatinous matter the product dries rapidly in air, but still better in chambers heated by the furnace gases. A great part of the heat is recovered by a recuperative system, an efficiency of 91 per cent being attained with a consumption of 1 kilo of coal for the production of 11 kilos of "tourbon." "Tourbon" can easily be made to contain only 20 to 25 per cent of water and may be used in place of wood for household purposes, in gas producers, or in distillation processes for the production of combustible gas and by-products (sulphate of ammonia, methyl alcohol, coke, etc.)

Peat, Wood and Lignite in Gas Making. (Gas Jour., vol. 138, 1917, p. 578.) Tests on the carbonization of peat at the La Villette works from 1861 to 1866 showed that 100 kilos of crude unpurified peat yielded 45 to 50 per cent of coke, 12 per cent of tar, 7300 cubic feet of gas per ton, and 38 gallons of ammoniacal liquor per ton. With purified peat the results showed 60 per cent coke, 15 per cent tar, 7500 cubic feet of gas and 46 gallons of liquor per ton. Experiments were resumed in 1887 and gave results showing a

variation in gas yield of 8760 to 12,191 cubic feet per ton and in ammonia yield of 2 to 4.1 kilos per 1000 kilos. The proportion of carbon dioxide in the gas varied from 16 to 25 per cent. In trials in Switzerland and Bavaria, the carbonization of wood in cast-iron retorts gave a yield of 10,800 cubic feet of gas per ton, 20 per cent of good charcoal, and 5 to 7 per cent of tar. Results of tests at Romarantin are also given. When used in a pure state the wood gas required a readjustment of the burners, but when mixed with coal it gave good results. Wood gas contains an appreciable quantity of acid, although very little sulphur, and the proportion of wood used along with coal is limited by the condition that the acids shall be neutralized by the ammonia of the gas, or corrosion of the works plant will result. In dealing with lignite it has been found practicable to use only a retort plant of the Woodall-Duckham type, the powdery nature of the residue necessitating a low temperature for its removal from the retort. The gas contains much sulphur and carbon dioxide. Up to 15 per cent of lignite gas with coal gas presents no difficulties in purification or consumption. As in the case of peat and wood, the nearness of a gas works to deposits of lignite is the factor influencing the possibility of employing this material.

Peat Gasification. (Thomas Rigby, Can. Pat. 179,008.) A peat-fuel mixture is obtained for charging a gas producer by moving a stream of peat or peat briquets containing about 68 per cent water and having the same meet a second stream of peat briquets which contain 5 per cent water and mixing the two streams to produce a material of the desired water content, the feeds being regulated to obtain the desired effect, so that any quantity of fuel can be obtained having a uniform distribution of moisture throughout its mass. The fuel is then fed into a hopper for feeding the gas producer.

Fertilizer Mixture. (J. J. A. and H. C. S. de Whalley, Br. Pat. 106,858, 1916.) A fertilizer is prepared by inoculating molasses or materials containing molasses with azotobacter or fertile soil containing azotobacter, lime stone, dolomite, dolomitic limestone or like alkaline earth carbonate in a finely divided condition being added to neutralize the acids produced. The mixture is allowed to stand for a few days at a temperature of 24°C. and may be used to inoculate a further quantity of the mixture or may be mixed with peat,

etc., so as to enable it to be readily spread on the soil. The molasses may be mixed with water or may be used in a concentrated form.

Some Effects of Organic Growth—Promoting substances (Auximones) on Soil Organisms concerned in the Nitrogen Cycle. (F. A. Monkeridge, Roy. Soc. Proc., vol. 89 B, 1917, p. 508.) Pure cultures of *Azotobacter chroococcum* from the soil, and of *B. radicicola*, the nitrogen-fixing organism of the nodules of leguminous plants, were cultivated in nutrient solutions to which were added small amounts of the different fractions of bacterized peat prepared as described by Bottomley. It was found that certain organic substances of unknown nature which could be separated from the prepared peat had an appreciable effect upon the rate of nitrogen fixation by these organisms. Similar experiments with nitrifying organisms in soil and in culture solutions showed that the addition of bacterized peat to a fertile soil caused a rapid increase in the proportion of nitrate up to a maximum, above which the growth of the organisms was inhibited by the concentration of the nitrate, and nitrification ceased. The rate of nitrification was greater in soil containing bacterized peat than in that containing an equivalent quantity of soluble ammonia in a form suitable for nitrification. The stimulation of the soil organisms does not depend upon the amount of nitrogen in the bacterized peat, judging by the effect of the phosphotungstic fraction upon the nitrification. It is probable, however, that the methods so far employed do not extract the whole of the auximones from the material. Although the auximone fractions accelerate the rate of nitrification both in soil and in culture solutions they have no influence upon the rate of ammonia formation. On the other hand, they reduce the rate of denitrification whether added to a pure culture of denitrifying organisms or to the soil itself. For example, whilst the amount of gas liberated in 48 hours by the soil alone was 63.0 c. c. that liberated by the same amount of soil to which the phosphotungstic fraction of bacterized peat had been added was only 8.1 c. c. The addition of an aqueous extract of the bacterized peat, however, has practically no effect upon denitrification, and it is suggested that this may be due to the depressing effect of the auximones being counterbalanced by the readily oxidizable organic matter contained in the soil.

Mr. Chas. Knap, Secretary,
American Peat Society,
Whitehall Building,
New York City.

Dear Sir:—

I, the undersigned, being interested in the development of our peat resources and in the welfare of the peat Society, beg to make application to membership in your Society, for which I enclose \$5.00 as annual dues.

Signed

Address

Date.....

Journal of the American Peat Society

Vol. XI

APRIL, 1918

No. 2

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OUR NEW SECRETARY.

At a meeting of the Executive Committee held on Dec. 14, 1917, at which our president, Mr. Luther B. Arnold, was present, it was unanimously agreed to appoint Mr. Charles Knap secretary-treasurer to fill the unexpired term of our late friend and member, Mr. Julius Bordollo. Mr. Knap has whole heartedly taken up this work and the committee feels that our members will not regret the appointment. Mr. Knap will make his headquarters at the old address, 17 Battery Place, New York City.

PEAT-FUEL PROBLEM.

More fuel! has been the soul cry of most centers during the past few months. We all know too well what the lack of fuel, or more correctly the inability of getting the fuel to its destination, has meant to each of us personally and to the community in general. The high prices that prevailed owing to the abnormal conditions brought about by the war has created an unusual demand for the development of peat-fuel plants for use in the neighborhood of peat deposits. This movement is not only national but international; our friend and neighbor, Canada, is even in a worse position than we are. Dr. Eugene Haanel, Director of Mines, Canada, has strongly urged the necessity of developing Canadian peat resources. The peat reserves of Canada are vastly greater than our own, Canada having at least 37,000 square miles of known peat deposits as compared to about 12,000 square miles in the United States. In a recent forceful address before the Commission of Conservation of Canada, Dr. Haanel again drew the attention of the Canadian people to the commercial and economic practicability of peat-fuel production. Dr. Haanel estimates, assuming an average depth of bog of 6 feet, that the

known areas of peat bogs in Canada correspond to more than 28 billion tons of peat, which would be equivalent to more than 16 billion tons of good coal. The work done in demonstrating the practicability of economically using peat is a problem which the fuel division of the mines branch, Ottawa, Canada, has successfully solved under the direction of Mr. B. F. Haanel, son of the Director of Mines, and his assistants. Mr. B. F. Haanel has brought all the information that the fuel division has obtained to the attention of our members at various meetings and through the pages of our Journal.

The development of our peat resources as a source of fuel should not involve any research work or experimentation, as economic processes for the manufacture of peat into good fuel are in use today, and have been for many years in several countries in Europe. The problem is not a question of experimentation but rather of adaptation. The many failures in peat enterprises, which are cited the moment the question of the commercial use of peat fuel arises, are due to misdirected energy and the general lack of interest by influential men. Because peat did not hold out fabulous profits, it did not attract the attention of large capitalists and industrial men. The industry has therefore been left to a few honest and serious men with insufficient capital, and, also, to unscrupulous promoters whose sole object was to sell stock. In many of the attempts to start a peat fuel industry failure might have been averted if the promoters had been wise enough to employ engineers who understood their business. Many plants have been started without taking into consideration the experiences of European practice; in many instances impractical and previously discarded ideas have been again tried out on an expensive scale, only to meet the same experience as before.

In considering the peat-fuel plant, there are several definite steps that are of prime importance and deserve both scientific and commercial consideration. The presence of a peat deposit does not necessarily mean that fuel can be made from it at a profit. In considering the development of a peat deposit as a fuel proposition, the first step is to determine whether the peat can be converted into fuel, for much of our peat is entirely unfit for fuel, and much of it is more valuable for other uses. If the chemical analysis and the fuel test have shown that the peat is suitable for making fuel, a competent engineer should be consulted as the most economic method of getting the peat out.

Every peat deposit has some peculiarity which generally prevents any one plant being exactly duplicated at another deposit; however, the experience of past accomplishments should never be disregarded. Experienced workers in this

line will be able to adapt existing methods and machinery to meet the needed requirements.

Peat as it comes from the bog contains 85 to 90 per cent water, and in converting it to fuel the only practicable process for the separation of this large quantity of water is natural evaporation by the sun and the wind. There are places, however, where waste heat is available for driving off part of the moisture, for instance, the sensible heat in peat gasification plants, waste heat in central boiler plants, etc.

In summing up, we can repeat the words of A. S. L. Barnes in *The Canadian Engineer*, in referring to the utilization of peat, that it is essential to employ only men with proper technical training for such work, in order to prevent the waste of capital inevitably connected with misdirected effort, and to avoid the many mistakes made in the past by persons lacking such training.

PEAT IN STOCK FOODS.

On another page is reproduced an article on this important subject by E. C. Dwyer through the courtesy of *Flour and Feed*, of Milwaukee, Wis. The use of peat in stock food is possibly the one least popularly known, despite the fact that it has been so used for several years. The use of properly prepared peat in the preparation of stock foods has undoubtedly an important future, and those who have had occasion to use such preparations claim that they have a decidedly beneficial effect on the health of the animals. Several years ago a member of this society, Mr. Ranson of Florida, stated that during an epidemic of hog cholera in the neighborhood he had no trouble with his hogs, which he attributed to the fact that they had free access to peat. It is of further interest to know that it cost the State of Florida \$27,000 for serum to fight the epidemic. It has been customary in Europe to use powdered coal for hog cholera and there seems every reason to suppose that properly prepared peat would be more effective. In Belgium the feeding of peat to stock has been practiced for years, and its value has been demonstrated over and over again.

Our President, Mr. Luther B. Arnold of Duluth, Minn., was in New York several days in December and conferred with the Executive Committee in regard to interesting the Federal Government building a gasification plant for the regeneration of ammonia. Mr. Arnold then left for Washington, D. C., to place the matter before the proper authorities, who promised to give the matter due consideration.

Field Operation in Relation to Peat

By John Olsen.

(Read at the Washington Meeting, Sept. 22, 1916)

The first steps in the preparation of peat are in the field, no matter for what purpose it may be used.

The methods employed on the bog will vary widely with the nature of the deposit and the products to be manufactured, but the one problem that is in common to all of them is the dewatering of peat by the natural action of sun, air, and wind. Too much attention is apt to be given to mechanical appliances for the purpose of excavating, conveying, and drying peat artificially, all of which are important, but no matter how well designed or efficient they may be, they can not compensate for the failure of utilizing the natural means of dewatering peat by its exposure to the drying action of nature.

It is well to bear in mind that peat after drainage still contains about 80 per cent water. If taken to the plant in this condition we are actually carrying for every five tons of raw material four tons of water and only one ton of solid matter, and worse still we have to pay out a lot of good money to get rid of the four tons of water after it is delivered at the plant.

We are apt to forget when we are handling peat just how much water we are handling at the same time, because we do not see the water in its familiar liquid state. When we handle raw peat we may mentally divide it into useful raw material and excess water. By useful raw material I mean a raw material containing the same amount of moisture that will be contained in the finished product. By excess water I mean the amount of water which must be evaporated before the peat can be utilized.

Then when the day's work is done we will not measure it by the number of loads or tons handled but by the amount of useful raw material obtained and charge against it the deferred cost of getting rid of the excess water. We may then discover that at times we are handling raw material which contains so much excess water that it costs more to get rid of the excess water than the finished product is worth.

Before beginning field operation we should determine the maximum amount of moisture at which it is necessary to gather our raw material in order to realize a profit on our products. The next problems would be these:

Is it possible to obtain raw material at this moisture and in sufficient amount to keep the plant in operation?

Moreover is it possible to get it during an unfavorable season?

How much area must we work in the field to obtain a sufficient supply?

How much raw material may be obtained from an acre during a season?

Is it possible to gather peat during a month in which the rainfall exceeds the evaporation?

These are all questions depending on a determination of the amount of water that may be evaporated in excess of the water added by rainfall and capillary action. It also depends on how far it is possible to diminish the effect of the rainfall and capillary action and increase the effect of the evaporation.

The amount of rain varies within wide limits from year to year, though probably averaging up in the course of ten or fifteen years. The rainfall is of course beyond our control, but its effect may be reduced by providing for proper surface drainage so that the run-off is increased to a maximum. Even at its best probably 75 per cent of the rainfall will be absorbed.

The movement of water by capillary action in peat is probably much less than in most soils, but if the ground water level is near the working surface of the bog, no doubt a large quantity of water is added during the season from the lower strata to the surface layer. This movement of water may be largely prevented by breaking up the surface layer of the bog as deep as possible, and preventing the peat from being compacted. Of course where it is possible and the expense is not too great, the water level should be lowered as much as feasible, though the added danger of fire should be kept in mind.

After all we have a very limited control over the effect of rainfall and capillary action. I believe we have much greater opportunity to increase the evaporation, and for that purpose a series of experiments might well be made, for instance by the Government (this would also apply to movement of water by capillary action in peat.)

The rate at which evaporation takes place from a given area depends largely on the amount of soil surface exposed. It may be several times the land area. This is just what is being done in Northern Europe where peat is made up in brick form and air-dried successfully. Not only the top of the bricks but most of the four sides are exposed and give a large surface for the action of the air and sun. How much surface area may be exposed on a bog where the peat is not handled in brick form, I can not say, but certainly by proper

working methods an area double that of the land area can be exposed.

For instance, in the vicinity of Boston, the average rainfall from May to October, inclusive, is 20 inches. The average evaporation from a water surface from May to October, inclusive, is 29 inches; or an excess evaporation of 9 inches, if we eliminate, for want of definite data, the run-off from the rainfall and the effect of capillary action, which tend to offset one another.

If the evaporation surface could be doubled and the rate of evaporation maintained we could have an evaporation of 58 inches instead of 29, or an excess evaporation of 38 inches instead of 9. This would probably be unobtainable in practice but if only one-half of this added amount was realized, that is, an excess evaporation of 23 inches instead of 9, we should be able to harvest peat at as low a moisture and as large an amount per acre as is now done in Europe.

It is primarily along this line that the successful solution of the peat problem in the United States lays, and only secondarily along the lines of mechanical equipment except in so far as it helps to obtain raw material at low moisture.

There can be no hard and fast rules how to accomplish this end, only experience with common sense can solve the questions; but if they are not solved satisfactorily and a sufficient amount of raw material obtained at the right moisture enabling the plant to fill orders when wanted by its customers, a peat enterprise can not be a success.

In conclusion I desire to sum up these remarks by quoting an extract from a letter sent me some time ago by the late Professor Davis, to whom we all are so greatly indebted for his unprejudiced and thorough study of the peat problems:

"It is beyond question too expensive to try to dry your peat without getting rid of all the water you can by sun drying on the surface of the bog. To my personal knowledge, millions of dollars, literally, have been spent in proving that this is true, and you can save your company money by accepting this fact as established without any farther investigation of the matter, unless you have some source of waste heat which can be used for drying purposes."

ITEMS OF INTEREST.

John N. Hoff has been in Florida several times during the past few months, having procured a peat deposit known as "The Meadows" near Ocala, Fla. This bog is one of great interest and we hope to be able to tell our readers more about it in a later issue.

MAKING AVAILABLE THE ORGANIC NITROGEN OF LEATHER, HAIR, WOOL WASTE AND MUCK OR PEAT*.

By R. E. Rose, State Chemist of Florida, Tallahassee, Fla.

Doubtless this question has been propounded to each of you, particularly those connected with the manufacture of commercial fertilizers or the official control of the sale thereof. In the latter capacity I propose to discuss the question, which has always been an important economic problem and which owing to the present scarcity of available nitrogenous fertilizer materials, caused by the enormous demand for nitrogen by the munition factories, has become acute.

Many of our States, including Florida, prohibit the "sale of any pulverized leather, hair, or wool waste, raw, steamed, roasted or in any form, as a fertilizer or as an ingredient of any fertilizer or manure, without an explicit printed certificate of the fact, etc." This law was enacted in 1901, and has not been repealed or amended, though it is well known to agricultural chemists that such waste materials properly "treated" are, very properly, used as an ingredient in commercial fertilizers; that when so "treated" they are no longer unavailable leather, hair or wool waste, etc., but by the "chemical treatment" generally employed have become sulphate of ammonia and humus; that by proper composting they, owing to bacteriological decomposition, are changed from insoluble to soluble or available ammoniate, nitrates or carbonates; that when composted (rotted) most, if not all, the organic matter becomes valuable available fertilizer or plant food. This "art" is one of the oldest and most generally practiced by successful farmers, who know "how" but not "why" properly composted vegetable and animal matter became a valuable manure or fertilizer.

Biological Chemistry.

No broader field of study and research has been opened to the scientist, the chemist or the biologist, than the study of bacteriology. To Louis Pasteur belongs the credit of making possible the modern science of bacteriology that younger sister of chemistry, long unknown or faintly foreshadowed as an essential factor in the study of chemistry.

Bacteria in the Economy of Nature.

I quote from the oration of Hiram Byrd, M. D., delivered

* Read at the Annual Meeting, Am. Chem. Soc. at Boston Sept. 10, 1917, and reprinted from *The American Fertilizer*.

before the forty-fourth meeting of the Florida Medical Association May 18, 1917, "Bacteria in the Economy of Nature":

"But the one great fundamental thing, the one undying heritage that he left the world, and which has meant more than Pasteur vaccination, more than diphtheria antitoxin, was his method of research, his scientific precision, his proof of proof. In a word he taught science to be scientific. Up to that time little proof was asked beyond the master's word—'He himself said so,' *ipse dixit*, was all-sufficient.

"Pasteur did not create germs—he didn't even discover them. They had been used before he was born to demonstrate the possibilities of the microscope. But he did turn aside to behold the burning bush. It was he, the master explorer, who said dig here and you will find gold. It was he who made bacteriology.

"It would be foreign to the subject I have chosen to deal with these organisms other than in the most general way, and in terms of their most fundamental attributes. * * *

"I use the term protein molecule to include the molecular components of all living matter. * * * Nor is the protein molecule of one substance the same as that of another—the protein molecule of wheat is different from that of corn, and that of animals different from that of plants, and that of one species of animal or plant different from that of another. But, differing as they do, they all have one attribute in common—they all contain the four elements above mentioned; many contain others, but all contain these (carbon, hydrogen, oxygen and nitrogen).

* * * "For green plants to supply their carbon, hydrogen and oxygen needs is a relatively simple matter and will not be discussed here. But not so nitrogen. Here indeed is a serious problem. Not that nitrogen is scarce in the world—far from it. Indeed nitrogen is one of the most abundant of all substances. * * * Seventy-nine per cent of the atmospheric air is nitrogen—enough to exert a nitrogen pressure of nearly thirteen pounds to the square inch. So I say it is not its scarcity that makes the nitrogen problem, but the fact that nitrogen is not usable in the gaseous form—has not yet had any energy injected into it, as the physicists say, it is in stable equilibrium. * * *

"The supply of combined nitrogen is not only limited, but even that is always leaking away, falling back into the free state. For nitrogen is at once hard to combine, and easy to set free, and the agencies setting it free are operating on a tremendous scale. * * * These bacteria convert the ammonia into nitrates, and the nitrates so formed become avail-

able to the roots of green plants. On the other hand the nitrates of the soil under certain conditions are converted into ammonia, and leak away into the atmosphere. The constant leakage of nitrogen from the combined to the gaseous form results in a nitrogen shortage for the plant world, and since animals depend upon plants for their supply of nitrogenous food, this shortage does not stop with the plants, but reaches the animal world as well. We may thus speak of the problem which besets all living things as the nitrogen problem. * * *

"Man has partially succeeded in solving the nitrogen problem in two ways. He has learned to take advantage of the combination of bacteria and legumes, and by crop rotation adds large quantities of nitrogen to the soil. In Germany it has been estimated by competent authorities that no less than a half billion pounds of nitrogen are added annually to the soil this way. * * *

"Every farmer knows from sad experience what the leaching of soil means. It means that his costly fertilizer, his nitrates, dissolve in the rain, and seep down into the ground, or wash away to the creek and join with the waters of the river on their way to the sea. * * * But why, you will ask, does not all nitrates eventually find their way to the ocean? The answer is not far to seek. Plants grow there as here. Nitrates function in the sea as on land. And while there is a current of nitrogen constantly flowing from land to sea, there is also a current flowing from sea to land. Our sea foods, and kelp, and other organic matters brought to land form a current of combined nitrogen, but that is of small moment compared to the current that is set free in the sea—set free by bacterial action to join the 79 per cent of the nitrogen of the air, thence to flow over the land and again be harnessed into action by the bacteria of the soil."

It is possible, indeed highly probable, that all the fixed or combined nitrogen found on this globe has been gathered from that vast sea of free nitrogen surrounding the earth by bacteriological action.

Muck or Peat.

Probably no substance on or near the surface of the earth contains, in the aggregate, more fixed nitrogen than does the vast peat or muck beds found in all parts of the earth, vast accumulations of vegetable matter, preserved from decay (oxidation) through ages by being constantly submerged in water, thus deprived of free oxygen and retaining their organic nitrogen intact. Vast areas of such peat or muck are found in all parts of the United States. Probably the largest con-

tiguous areas are found in Florida. Not only that vast expanse the Everglades, comprising a territory one hundred miles long by fifty miles broad, 5,000 square miles or more than 3,000,000 acres of muck or peat from four to twenty feet deep, averaging probably six feet deep, recently an impassable morass now largely reclaimed by drainage and rapidly being occupied by a prosperous people; but also numerous small drainage projects, some eighteen in number, embracing from 20,000 to 300,000 acres each of similar soils, in Florida alone; with vast areas of similar soils on the Atlantic seaboard, in Georgia, the Carolinas and Virginia, in Louisiana, in Michigan, Minnesota and other States.

The average nitrogen content of these muck or peat soils is above three per cent. Recently an effort to utilize this peat in the production of gas for power and the conservation of the nitrogen as a sulphate has been demonstrated as practical and profitable.

Experiments of Prof. Bottomley.

The recent experiments by Prof. W. B. Bottomley, of London, as described and illustrated in a recent issue of the Scientific American and other journals, tends to establish the fact that bacterial action will not only make available the organic nitrogen in peat, but that additional quantities of available nitrogen are evolved, or fixed in the material by this bacterial action.

That muck or peat drained and thus oxidized yields its nitrogen in an available form for plant food, that the percentage of nitrogen found in such drained (or composted) muck is greater than that found in the original, has, I think, been practically demonstrated. How far this process may be carried or how great an increase in fixed nitrogen as ammonium sulphate, chloride or carbonate, can be obtained, is still problematical. The results so far reported are by no means concordant. This is readily accounted for by the difference in methods, in appliances, apparatus and the environment and opportunities of each investigator and observer.

A Field for Investigation.

That there is a vast and profitable field for investigations by the chemist and the biologist in this field of increasing the fixed nitrogen of our vast deposits of peat or muck, and at the same time making the same available to plant life, is unquestioned.

This is properly a problem for our Agricultural Experiment Stations who have (or should have) the necessary

apparatus, facilities, time and the co-operation of various specialists in chemistry, bacteriology, biology, etc., to determine the "reasons why," which when discovered, will soon be followed by "methods how" to economically increase our supply of available nitrogen now locked up in vast quantity in our peat beds.

Recent experiments in making available the enormous amounts of unavailable nitrogen in the newly drained, still undecomposed muck soils of Florida, by adding a very small amount of stable manure (a few hundred pounds per acre) thus introducing live bacteria, have resulted in unusually large crops; while on identical, adjoining soils, without this added bacteria (yeast) failures were the rule, until time (months and years) had elapsed in which natural decomposition, bacterial action, had occurred. That this natural decomposition can be hastened by sterilizing to destroy the denitrifying organisms and by the addition of proper chemicals to form a medium favorable to the growth of nitrogen-forming bacteria, has, to an extent, been practically demonstrated. While the unavailable nitrogen has been made available, there has also been shown an increase in the nitrogen content of the original material. Specimens of raw peat, showing an average of 3 per cent total unavailable nitrogen, after treatment have shown a much greater percentage of nitrogen, found available. Whether this increase was caused by concentration of nitrogen or by free nitrogen of the air being fixed in the specimen, I am not prepared to say. I can say the percentage of nitrogen was materially increased and its availability largely increased. There are several investigations now in progress to, if possible, make available the unavailable nitrogen of peat or muck and to increase the percentage by bacterial action and the addition of proper chemical media.

The Value of Muck.

Considerable interest has always been shown as to the value of muck as a fertilizer or manure. It has had able advocates, and equally as able detractors. Reliable experimenters have reported excellent practical results; others equally as reliable have reported absolute failures to obtain any valuable results.

It is but a few years since the scientist, the chemist, biologist and particularly the bacteriologist have begun to study this problem. Just at present the demand for available organic nitrogen, particularly for fertilizers, is acute. The discoverer of a practical, inexpensive method of making avail-

able the unavailable nitrogen of peat and possibly increasing the percentage thereof, will confer a boon upon humanity and it is to be hoped will also secure a substantial material reward, as well as honorable mention.

The paper presented at the meeting of the American Bacteriological Society, at New Haven, Connecticut, December 27, 1916: "The Importance of Mold Action in Soils," by P. E. Brown, of the Iowa Agricultural Experiment Station, as published in Science, August 24, 1917, shows that these problems are beginning to attract the attention of the scientists of the Experiment Stations; questions peculiarly within the province of the Experiment Stations particularly such as are located in those States having immense beds of peat or muck containing vast quantities of nitrogen, waiting for some investigator to render it available in the production of food and forage; and to an extent relieve our farm of the present nitrogen hunger.

BACTERIZED PEAT.

At the request of Mr. Robert Ranson of St. Augustine, Fla., we are printing herein a letter which will, no doubt, be of interest to our members who read the Rothamsted Report on Humogen, which was published in the American Peat Journal in 1917 (Vol. 10, p. 126).

ROBERT HOLMES

Tuckswood Farm, Norwich, England.

November 15, 1917.

Dear Mr. Ranson:

I was pleased to have your letter a few days since and embrace the first opportunity of replying.

In the first instance, I judge by your remarks that you have not received a letter that I wrote you a long time ago, apart from the additional fact that you make no mention of having received this letter, which I can only conclude must have been lost in transit. Unfortunately I have no copy of this letter nor a record of date of postage, the same not being a business letter.

It is not, as you assume, any question with me of whether or not I have lost faith in "Humogen," for "before Humogen was, I was." My dealings with soil bacteria date back for 20 years at least; it was, I think, about the first year of the present century, that I wrote articles urging the importance of recognizing the work bacteria carry on in the soil, etc.

I will post a copy of a book I published about that time on "Fertility of Soil" which shows my knowledge of the sub-

ject at that date. My own practice has been to increase the value and usefulness of stable manure by careful treatment with a view to multiply the numbers of bacteria and in particular to develop the nitrogen fixing groups. Humogen, I take it, is simply the same thing or at least a similar product produced from peat instead of straw manure.

But to commence my letter in reply to yours let me explain that in 1915 Professor Bottomley sent me some good "humogen" for trial, at least sometimes it was good and sometimes bad. The explanation given, as I remember it, was that the plant was merely a temporary expedient worked by a man and a boy, and that sometimes the material was found to have become overheated during the process of artificial drying and then overheated creosote was formed, which was injurious to plant life, etc.

It was also explained that when manufactured at a specially designed factory the material would be standardized and all would be well. Naturally, the next year, 1916, when the material was made at two such specially prepared factories, I expected and did not for a moment doubt but that the material would be uniformly good or better.

I undertook the sale on trade terms and sold a quantity before my own trials of 1916 were sufficiently developed. However, my tests on plants quickly showed that something was wrong and I was early able to tell the makers and all concerned that the material was useless, indeed, I said much more, and subsequent tests confirmed my first experience. It took me a long time to convince everyone, indeed, I told them all what would be the result of the Rothamstead and other trials. It was not until the latter part of the summer that I was able to convince the makers and to prove their mistakes, which I think you will have seen by the addenda attached to the Rothamstead report, written by Professor Bottomley, explaining that the material that had been made and sold under the name of "humogen" was not bacterized peat at all but was chemically prepared peat. I think that the chemical (which I do not feel I would be justified in naming) destroyed all bacterial life.

As I explained, I told the interested parties six months in advance what the results of all the public trials would be. Of course, an alteration was promptly made and I hope all will be well with this year's make, but I think the labor shortage has been a trouble.

I am bound to acknowledge that the makers treated me well. They told me to make out my bill and to charge for advice and assistance rendered. They not only paid me

promptly but thanked me sincerely for condemning the material and for giving a much worse report than that from Rothamstead.

I am pleased to have your appreciation of Prof. Bottomley's work and you are quite right. I could tell you much more but I forbear on this occasion at least. I would like to see the report, or rather the criticism of "humogen" in your "American Peat Journal" as disclosed by the Rothamstead experiment—perhaps you will post this to me.

You will understand that the great World War is taxing our strength and I have not attempted any experiments or trials with "humogen" this year, but I shall do so to justify my "faith in humogen," as you have put it.

I thank you for your letter and with kind regards, believe me to be

Yours faithfully,

(Signed) R. HOLMES.

FERTILIZING PEAT SOILS.

The Indiana Agricultural Experiment Station, in Circular No. 66, by S. D. Conner, make several recommendations for the fertilizing of various peat soils, which are extracted below:

Muck and peat soils of slight acidity. Although these soils are slightly acid, they do not respond to limestone; they do not need nitrogen or organic matter, and it is not necessary to grow legumes to keep up fertility. The principal needs are potash, and to a lesser extent, phosphate. These soils may be cropped continuously with corn for many years if they are supplied with potash and phosphate.

Muck and peat soils of medium acidity. The higher the acidity of muck soils, the greater is the need of phosphate. Some soils of this type respond to phosphate and not to potash. Limestone is not usually necessary, as legumes are not needed on this type of soil.

Muck and peat soils of high acidity. These soils are sometimes so very acid that they are almost barren of vegetation; phosphate is deficient, and limestone is needed in proportion to the acidity. Sometimes 10 to 20 tons of limestone, together with phosphate, are necessary to grow corn on acid muck. Potash is often needed in addition to phosphate, but nitrogen is not needed.

Muck and peat of no acidity. These soils are almost always deficient in potash. They do not need limestone and seldom need phosphate. Nitrogen is not needed, as it is present in large amounts; in fact, such soils are sometimes so

well supplied with nitrate salts that they are unproductive. Such soils are often coated with a white crust in hot, summer weather, when they dry out after a rain. The nitrates and other salts that tend to accumulate at the surface, are sometimes so concentrated that young corn and onion plants are killed. Such soils should be seeded to pasture or to hay crops until the nitrates become less abundant.

PEAT MAY HELP SOLVE FUEL PROBLEM IN CANADA.*

"The people of Canada," said Mr. B. F. Haanel, chief of the division of fuels and fuel-testing, department of mines, Ottawa, at a meeting of the Montreal branch of the Society of Chemical Industry, held recently at Montreal, "and especially those living in Manitoba, Ontario and Quebec, must realize how dependent they are upon the supply of coal from the United States. This coal supply, so necessary for sustaining life and industry, does not come from an inexhaustible source; even in our lifetime we may see this supply suddenly cut off.

"Canada, however, has an enormous reserve of fuel lying undeveloped in her peat bogs, which are situated mainly in Ontario and Quebec. The mention in the past of peat fuel to people of Canada or the United States recalled to their minds the story of the financial failure of company after company which promised great things at the start, but which, in turn, ended in the same way, the money spent and no cheap fuel supplied. Today the story is different. The Federal department of mines has demonstrated that a cheap and satisfactory fuel for all domestic purposes, as well as for many metallurgical operations, can be manufactured from the peat bogs of the country.

"The success of the peat fuel industry in this country, or in any country, depends upon the employment of known and tried methods of manufacture by qualified engineers, especially trained in this particular line of work. The manufacture of peat fuel is a successful industry in many European countries, where they employ but one method, namely, the 'wet process.' The 'wet process' is the one recommended by the department of mines, and is the only one in successful operation today.

"'Peat fuel, as it occurs in nature,' said Mr. Haanel, 'contains 80 to 90 per cent of water. This water content must be reduced to between 25 and 35 per cent before the peat can be placed on the market as a commercial fuel. The use of pressure or artificial heat, or both together, has always proved a failure for reasons both physical and financial. 'The wet

process' employs the sun and wind to dry the wet peat as received from the bog; both these agents are ever ready and cost not a cent for their use.

"Peat fuel, besides being a substitute for coal for domestic and industrial uses, is a valuable source of nitrogen for the manufacture of ammonia and other nitrogen compounds, such as are used in fertilizer."

*Through Canadian Engineer.

PEAT FUEL AT MOSCOW FOR MAKING ELECTRICITY.

We learn from the "Electrical Review" that the Assistant Minister of Trade and Industry, N. N. Savin, has proposed to the Provisional Government to grant a loan of 2,000,000 roubles to the Elektro-peredatch (Electrical Transmission) Co., Moscow, for a period of nine months, at 8 per cent annual interest. The memorandum accompanying the proposition states that the company delivers 40,000,000 kilowatt hours per annum, almost entirely for industrial purposes, the fuel used for the production of this power coming from the company's peat deposits. In the current campaign the company contemplates using 113,000 tons of air-dried peat, and the wages of the peat workers have risen about threefold. It is the increased wage list that necessitates the advance of cash asked for. The difficulties of the company were further accentuated by the overthrow of the government while the station was in course of construction. On this account, and also because of the proposed elimination of foreign-capital interests, the plans made earlier for financing the concern could not be carried out. The Minister adds that last year 70 per cent of the work done by the company was for the national defense, and a considerable percentage of the energy delivered by the Moscow 1886 Company could, if the peat were properly exploited, be delivered by the Elektro-peredatch, and a corresponding consumption of petroleum be avoided. For the reasons stated, the Ministry considers that the loan requested should be granted.

(Through Indian Engineering.)

Will members of our Society and readers of our Journal please look through their files, and if they have any spare copies of the April, 1913, number (Vol. 6, Issue No. 2), kindly communicate with the Editor.

Mr. George W. Hall of North Adams, a member of our Society, has purchased the Dolberg Peat Press from the estate of the late Carl G. Kleinstueck, former member and past president of the society.

The Peat Bogs of Canada

By Joseph E. Armstrong.[†]

It may be safely said that there will be no permanent reduction in the price of coal; rather it is reasonably certain that there will be a gradual but steady increase. Fuel will become higher as the years go by. The cost of development of heat from water power, in addition to maintenance and management, does not encourage us to believe that we will be able to use electricity as a poor man's fuel for many, many years to come. The price of anthracite and other coals is advancing largely because of exhaustion of the thicker beds, and increased costs of working, freight and transportation facilities. Anthracite coal is fast becoming the fuel of the rich.

In addition to this, manufacturing establishments are bound to increase and the coal consumption for power purposes will likely develop more rapidly. As coal becomes dearer, the difficulty and uncertainty of the supply becomes more accentuated, and the importance of a substitute fuel becomes more urgent. If, therefore, the great peat bogs of Canada could be successfully converted into fuel which would be cheaper than wood or coal the advantages thus conferred upon the future inhabitants of Canada and the United States could hardly be overestimated. The difficulties to be overcome do not appear to me to be very great when the attendant benefits are taken into consideration. The kinds of fuel available in Canada are: The wood still standing, our oil deposits, the oil contained in oil shales, gas, lignite coal, water powers (or white coal), anthracite coal, bituminous coal, and our peat deposits.

Peat is incipient coal. It is made up of the more or less thoroughly decomposed and carbonized remains of plants accumulated under conditions that have prevented their complete transformation into gaseous and mineral matter. The successive stages in the process of carbonization, as it is reported in nature, is first peat, then lignite coal, anthracite and graphite, a form of carbon. For centuries, peat has been extensively used for domestic fuel by the peasantry of northern Europe. An important source of additional fuel for the more immediate future in Canada exists in our extensive peat bogs. These, and the great lignite areas of the northwest occupy a middle ground between coal on the one hand and such vegetable fuels as wood, etc., on the other.

*Extracted from the Canadian Engineer, Feb. 28, 1918.

[†]Member of the Canadian Parliament.

Peat Gave Satisfactory Service.

For many years past efforts have been made to develop the peat areas in Ontario and Quebec. A large amount of money was frittered away by careless and useless endeavors to produce this material in a manner in which it might be marketable. However, some six years ago the government decided to make a practical investigation into the peat producing areas of our country, and, if possible, demonstrate the advantages to be derived from peat production. They sent representatives to Holland, Sweden, Denmark, Germany, and Russia to gather data and material that could be utilized to advantage in Canada. On the return of these representatives the government purchased 300 acres of the peat bog at Alfred, about forty miles out of Ottawa, and prepared to demonstrate the commercial feasibility of the manufacturing of peat fuel by the employment of a process which is well known in Europe, and which was the only process for manufacturing peat economically. The government manufactured 2,000 tons of peats in that bog; they sold this peat in Ottawa and vicinity to householders and manufacturers for the purpose of introducing that form of fuel to the public and to obtain expressions of opinion regarding this fuel for domestic purposes. The various users of this fuel almost invariably expressed their satisfaction with peat as fuel. They further expressed their keen desire to continue the use of this fuel. I have 150 letters from people who used peat as fuel, and, with the exception of two or three, all speak in the highest terms of its heating qualities, its economy and efficiency.

After the completion of their experimental work, the Mines Branch felt that they had accomplished all that they should do, that is, the demonstration that this peat could be manufactured at a low cost and transported economically, and that as a fuel it was satisfactory. The Mines Branch felt that further development should be left to private individuals. They disposed of the plant and acreage to a firm who commenced the development of the industry. The private individuals then made some improvements to the plant, and during the year 1914 expected to carry on extensive developments. They were well under way with this work when the war broke out, but being supplied with a limited capital, they were seriously handicapped, and were compelled to close down their plant for lack of money to continue its operation. I regret to say that the plant is now in the hands of a receiver.

From the government's development of the peat bog at Alfred, it was proven conclusively that peat could be manu-

factured into blocks suitable for use in industries and in private homes at an actual cost of \$1.75 per ton.

That was the price manufactured on the ground. Indeed, this was the actual cost of the production of the 2,000 tons of peat referred to. The railway charged one dollar per ton for its transportation to Ottawa, a distance of forty miles.

However, the peat was delivered at \$5 per ton to manufacturers and householders, and from many sources I have obtained definite information sufficient to assure me that for residential purposes, in grates, in cook-stoves, in the ordinary heater, this has proved to be an ideal fuel. This is a practical demonstration of what can be accomplished, and a good reason why the government should act. It is true that anthracite coal has more heat units per ton, but the use of anthracite coal entails greater wastage, owing to incomplete combustion, and a larger percentage of ash. This is not necessary in the consumption of peat. Peat fuel is easily lighted, and it is not necessary to use a greater quantity than is required for cooking or heating at one time, while, on the other hand, anthracite undergoes very great wastage in this regard.

Russia Uses Peat.

The sale of machines for the manufacture of peat in Russia in the years 1912 and 1913 shows an increase of 400 per cent. It is estimated that Russia is producing annually ten million metric tons of peat fuel, out of which seven million tons are manufactured in the seven central Russian provincial governments. The United States, exclusive of Alaska, is estimated to have 11,200 square miles of peat bogs, averaging nine feet in depth, and containing nearly 13,000,000,000 tons of fuel, worth, at \$3 a ton, \$39,000,000,000. Canada has 37,000 square miles of known peat bogs, but these form probably but a small fraction of the total, constituting a potential national asset of enormous value. The peat resources of Canada exceed those of any other country with the exception of Russia. During the period from 1908 to 1914 the Mines Branch in Canada located, mapped and investigated 140,000 acres of peat bogs in Ontario, Quebec, Nova Scotia, Prince Edward Island and Manitoba, all convenient to railways and markets, estimated to be capable of yielding 115,000,000 tons of fuel and \$10,500,-000 tons of peat moss litter. Why do we not make use of the information obtained by our government experts? Seven Ontario bogs within convenient shipping distance of Toronto will yield 26,500,000 tons of fuel. Four bogs within a few miles of Ottawa are estimated to contain over 25,000,000 tons. Seven bogs in the Montreal district could furnish that city with 23,500,000 tons of fuel. Five bogs along the St. Law-

rence, below Quebec and convenient to that city by water, could supply 16,250,000 tons of fuel and 5,750,000 tons of peat moss litter. Nova Scotia bogs examined in Yarmouth, Shelburne and Lunenburg counties will produce 6,250,000 tons of fuel and 500,000 tons of litter. Six bogs investigated in Prince Edward Island can furnish 1,250,000 tons of fuel and over 1,000,000 tons of litter. Seven bogs examined in Manitoba will produce 2,000,000 tons of fuel and 2,500,000 tons of litter.

As to the comparative heating value of peat fuel as delivered to the consumer, it may be said that, comparing the actual heating values, one ton of hard coal is equivalent to 1½ tons of peat with a moisture content of 25 per cent.; but, in order to arrive at a fair comparison, it is necessary to understand and carefully consider certain factors which, under certain conditions, would turn the scale in favor of peat fuel. As a fuel for cook-stoves, ranges, etc., peat fuel will prove more economical than anthracite, since, with coal, the fire must be burned continuously, and, moreover, the refuse, i. e., ash, contains a very large proportion of combustible matter.

The manufacture of sulphate of ammonia is a matter of great importance to the people of Canada. Our peat bogs in Canada are high in nitrogen, running about two per cent. In Italy they are running their peat bogs with a little over one per cent. of sulphate of ammonia. Ammonia sulphate is a very valuable artificial fertilizer, for which there is a continually increasing demand in almost all parts of the world, and a ready market could be found for all the sulphate of ammonia that could be produced in Canada.

At a time like the present, when stock is being taken of the natural resources of the country, the importance of these investigations will be readily recognized. The estimated yield of 19 bogs in Ontario and Quebec, if used to produce ammonium sulphate, would give a production of 81,696,416 tons of fuel. With a production of sulphate of ammonia amounting to 4,025,525 tons at a valuation of \$65 per ton, which is a very low estimate, the value would amount to \$261,659,775.

Intense agriculture has filled the granaries of the world, but fertilizers have become absolutely necessary. Soil fertility is urgently demanded. Appetite has come with eating and our demands and wants are increasing day by day. Inoculation of soil has become an established success. Bacterized peat has been used most successfully as a medium for this purpose. Experiments in England made by Professor Bottomley, Botanical Laboratories, University of London, Kings College, as described in a book entitled, "Spirit of the Soil," written by C. D. Knox, shows that treated peat gives as much

as 50 to 80 times greater results than the best rotted stable manure, that it is free from smell, dust, weeds, disease spores and insect pests, is clean and pleasant to handle. After seven years of experiments, the American Board of Agriculture are distributing a similar preparation to farmers and recommending its use. Bacterized peat opens a field for every farmer and gardner to undertake important scientific work, in order to increase the yield from the land.

In addition to this, Dr. Eugene Haanel, the head of the Mines Branch, makes the following estimate:

That the gas available in working the large Teefield bog for sulphate of ammonia would produce 4,000 h. p., continuously for 86 years, a total of 344,000 h. p. The total power gas available in conjunction with the utilization of all the bogs in Canada would amount to over 5,000,000 b. h. p.

Peat burns with a much smaller air supply than coal, consequently less heat is wasted than with the greater draft required to burn coal.

The Duty of the Government.

I believe it is the duty of this government to take over certain peat bogs and lignite mines and furnish the material at cost to our people. Greatly increased prices for the coming winter must be expected, and unless some immediate action is taken, great hardships are bound to ensue. The peat bog at Alfred, Ont., is capable of immediate development, and at least 1,000 tons of peat per month could be manufactured in this bog during the summer and fall. After the material is manufactured, it is up to the municipalities to purchase the peat and see that it is delivered at cost.

In the western provinces, lignite coal should be made available for distribution and I believe that a sufficient quantity of soft coal should be brought from the mines at Sydney or thereabout, up the St. Lawrence, and distributed to the municipalities, if for no other reason than as an experiment. The day may soon come when elevators will be built in Sydney harbor and boats carry coal west and wheat east. I cannot urge too strongly on the government the need of immediate attention to this whole fuel problem.

WISCONSIN PEAT.

On account of the coal shortage it is understood that the Merchants' and Manufacturers' Association of Milwaukee are about to investigate the peat deposits in Wisconsin with a view to their being used as a commercial fuel.

THE FUEL SITUATION IN SWEDEN.

The present scarcity of fuel in Sweden, especially for traffic and industrial needs, has brought forth many plans for the production of substitutes for coal and a better utilization of domestic fuels, especially the vast deposits of peat in that country. Experiments with the manufacture of ordinary peat fuel, peat powder, peat coke, peat gas, and the like have been continued.

The latest effort in this direction is mentioned in the "Goteborgs Handels-och Sjofarts-Tidning," Goteborg, for November 1, 1917, an article, the translation of which follows:

An application has lately been filed for the organization of a company in Malmo, the purpose of which is to produce peat coke and by-products according to methods invented by Dr. W. Wielandt. The capital stock, which is to be not less than 5,000,000 crowns (\$1,340,000) and not more than 15,000,000 crowns (\$4,020,000), has already been subscribed privately.

The Wielandt method originated in 1902, when two German scientists, Prof. Paul Hoernig and Dr. W. Wielandt, commenced, in Oldenburg, their extensive investigations regarding the chemistry of peat, of which at that time almost nothing was known. On the basis of the data obtained from the analyses and laboratory experiments, the first factory for peat distillation was built at Elisabethfehn in 1905. There were regularly produced coke and by-products, such as sulphate of ammonia, wood alcohol, acetic acid, tar, motor oils, lubricating oils, creosote, paraffin (soft for match factories, hard for candle factories) and asphalt (pitch). Further, the peat gases were used for production of electric power and for heating the ovens and distilling retorts.

The coke that can be produced by the Wielandt system is an excellent fuel with about twice the calorific value of ordinary peat fuel or peat powder. It burns without smoke and with little draft, and leaves no slag. It is, therefore, an excellent household fuel, and can be used alone or mixed with charcoal, in the production of high-grade iron. It is considered to be especially useful in the electric smelting of iron.

The cost of production is low, owing to the value of the by-products obtained. In manufacturing on a large scale, the cost price will probably be 10 to 12 crowns (\$2.68 to \$3.22) per ton.

The by-products play an important part; for the creosote can be used for preserving wood (railroad ties, etc.), and the other by-products, such as oils and paraffin, are equally important.

Improved Methods for Producing Peat: The chief re-

quisite for an economic production is a sufficient quantity of air-dried peat at a low price. In using the Wielandt automatic excavating machines not more than 80 men are required for an annual production of 100,000 tons of air-dried peat. Otherwise a force of 800 men would be required for the same production. John Hallmen, the manager of the Government Peat School, who has seen the Wielandt establishments and has thoroughly studied the system, states that this method ought to be of assistance in solving the peat question in Sweden, especially as the by-products are of great importance and can be obtained in such quantities that they ought to contribute considerably toward the supplies needed in this line.

There are in Sweden more than 5,000,000 hectares (12,355,220 acres) of peat bogs. If only 2 per cent of this peat were suitable for the Wielandt industry, this would give 200,000 hectares (494,209 acres) net. With an estimated depth of 2.5 to 3 meters (8.2 to 9.8 feet), about 1,000,000,000 tons of air-dried peat can be dug from them. If a profit of only 20 crowns (\$5.36) per ton were gained in utilizing the Wielandt method, this would yield a direct national profit of 20 milliard kroner (\$5,360,000,000) in addition to the indirect profit.

(This process is described in the Journal, Vol. 6, p. 3.)
(Consular Report.)

HIGHER PRICES FOR PEAT FUEL IN IRELAND.

The Colliery Guardian (British) states that in the west of Ireland, where peat is the staple article for fuel, the price has risen from \$1.20 a horse load to \$3.60 and \$4.00.

THE FORMATION AND CHARACTERISTICS OF MASSACHUSETTS PEAT LANDS AND SOME OF THEIR USES.*

By Dr. Alfred P. Dachnowski, Washington, D. C.
(Delivered before the Massachusetts Horticultural Society,
January 27, 1917.)

Reference to any good topographic map of Massachusetts will show a surprisingly large number of unimproved peat lands favorably located to various important market centers and to the chief lines of transportation radiating from Boston. In no state of the Union is the development of peat land resources for their food yielding value of greater importance than in Massachusetts, where agriculture in the last 5 years has seen a great change and in the further growth of which are interested the commercial and industrial prosperity of over 4,000,000 people.

The passage of legislation by the State Board of Health for the drainage of some of these peat lands and the establishment of a provision to extend the activities of the drainage engineers to aid in the preparation of peat lands for agricultural and other purposes constitutes a notable recognition of agriculture in a new direction. Not only does this imply the harmonious working together for ends of a common good, but more primarily the realization that the great peat land areas can be made a valuable resource to the state only through well planned measures controlled by State Departments working in co-operation.

Today the great increase in population demands the use of peat lands for the growth of crops and for various industrial purposes. But the very factors, however, which have brought about this great accumulation of vegetable material, and which constitutes a gain in land as against the loss upon mineral upland by erosion and leaching, may also introduce with them certain possible sources of failure. The great profits obtainable from the cultivation of truck crops may lead to the use of certain kinds of peat land at the expense of other types of farming which would be less liable to failure or to dangerous limitations. The desire for rapid returns may not in a few instances encourage the landholder to ignore the wise rule of crop adaptation through crop rotation with suitable varieties; he may fail to heed the decreases in yield which follow a lack of knowledge of the different peat materials and their characteristics, especially the changes in con-

*Reprinted from the Trans. of the Mass. Hort. Soc. 1917.

ditions, such as the water table whose influence requires close and continuous study.

It would be well, therefore, to consider what is the position of Massachusetts in this matter of peat land utilization and what work should be done towards obtaining a fair degree of success in local areas with peat lands differing in material and in field conditions.

Several important elements enter into the problem under consideration, which for convenience are named (1) the influence of vegetation; (2) the influence of climate; and (3) the geological and topographic factors.

I. The Influence of Vegetation.

The native vegetation which covers the peat lands of today presents to the careful observer unmistakable features in regard to the predominating plant associations forming peat materials and the diversity of habitats which they reflect. Their various growth forms are correlated in the main with variations in the ground water table and they represent distinct effects in the method of building up strata of peat. Changes in the character of the indigenous vegetation of peat lands are as a general rule very slow under ordinary circumstances. This fact is so striking that the appearance of certain bog plants should serve the intelligent farmer not only as an index to environmental conditions and their products but also as a guide in the selection of his farm practice.

It is well known, however, that commonly the variations in peat materials over the surface area, and the nature of the sub-surface materials are rarely if ever examined in any detail, and are often entirely omitted from observation. Whether or not peat materials consist of layers of vegetable debris easily penetrated by roots of crop plants, by water and air so that they will weather, shrink and yet drain readily, or whether root penetration is limited by beds of material unlike in composition and degree of disintegration, such as layers of plastic peat derived from aquatic plants or formed under periods of flooded and high water conditions; layers of granular material resulting from woody shrubs during periods of excessive drought conditions or following drainage changes; whether distinctions in the materials arise on account of strata of windfallen timber or of drifted impurities, such as ashes, silt, clay, or marl, the amounts of which depend on the currents of streams and rivers, their flooding power, etc.; whether plant growth and crop yield are influenced by a hardpan of fine-grained organic material or by one arising from compounds with lime or with iron; whether the contact layers of peaty material with a bot-

tom of sand, gravel, clay, diatomaceous earth, or marl are continuous or not, and whether the mineral soils below, or those along the margins of the peat land, indicate predominantly solution and bleaching action or a deposition and "staining" process with mottled coloring,—all these points are of the greatest practical import. Marked physical differences arise from the several materials which undergo disintegration, in the relative abundance of that indefinite, fine-grained debris which plays the role in distinctions between heavy and light peat lands and which gives a certain degree of adhesive plasticity, but under some conditions render the surface peat soil almost impervious to water, probably due to the absorption of air.

The physical nature of the different peat and muck lands of the state and their respective substrata materials are doubtless of the widest practical importance, since it is in general more difficult to change the nature of the vegetable mass than to remedy the chemical deficiencies. Aside from the modifying influences of field conditions this is probably one reason why a chemical analysis of an organic soil is generally of little value in establishing relations to crop productivity. It is necessary, therefore, at least in somewhat more detail than undertaken hitherto, to understand the differences in the respective groups of peat lands, the phases of their materials and the field conditions under which they were formed. A profitable use of them can be made with related cultural methods and a choice of suitable crops. How important a detailed investigation may become to Massachusetts and for that matter to any other state, in view of the existing great geographical differences in climate, geology, and vegetational influences affecting the character of peat lands and their agricultural and industrial possibilities, is readily apparent.

The role of vegetation in the conversion into peat lands of water basins or of wet depressions on uplands, along rivers, or at the coast has long been recognized, but the sequence of plant associations forming peat, the possible retrogressions, the origin and the conditions giving rise especially to ericaceous heath-bogs, and lastly the manner in which peat accumulation takes place are still problems at present under much discussion by investigators.

The general conclusions formed from one point of view lead, briefly stated, to the following: In common with other glaciated regions the origin of the modern era of plant life in Massachusetts dates back to the period when the continental glaciers receded toward the North pole and vegetation from the south and west once more migrated northward in the

wake of the retreating ice sheet. During the time that has elapsed since the recession of the ice front, variously estimated at from 30,000 years for southern states to 20,000 years or less for northern states, many plant societies have doubtless occupied this region, which at the present time are characteristic of regions farther north. Thus the first vegetation to seize upon the areas which became exposed gradually may have been quite similar to the tundra of the far north, extensive, compact mats of herbaceous plants, and woody, prostrate forms, shrubby in appearance and chiefly of the ericaceous family. Following the tundra there developed slowly, it is presumed, a type of bog shrub stage and later one of temporary climax vegetation similar to the spruce and fir forests, which still comprise an important element on the peat lands of northern Massachusetts. Last of all followed in their northward march components from the southern coastal district, and from the plateau regions the deciduous and hardwood trees and their dependents, which at the present time predominate on the peat lands of such states as Ohio and Indiana.

Deciduous trees and some of the plants associated with them have now, that is within very recent geological time, regained only a position of their original home; they have commenced to invade this region and are establishing themselves in the more favorable sites, thus giving rise to a mixture of coniferous and deciduous forest type of peat lands, transforming them into a new and different habitat. But the conquest of some of the former lakes, ponds, and inundated depressions along rivers and the coast is still going on and many of the isolated plant associations still survive as the remnants of a more northern type of plant succession. Coastal cedar swamps and river marshes are quite suggestive of this fact, for the cranberry sphagnum type of bog meadow described elsewhere as one of the members in the classification of peat lands (Ohio Geological Survey, Bull. 16, 1912), is of frequent occurrence as the ground mat where boreal, certain austral, and even several maritime plants may find conditions for growth and establishment. There is abundant evidence tending to show that southern plants seem to be gaining the ascendancy and that wherever suitable changes in drainage and weathering ensue, spruce, fir, tamarack pine, and cedar become replaced largely if not entirely. Red maple, elm, ash, and others are contributing more and more to the increasing complexity of peat materials.

Very much of what we wish to know about the composition of peat materials, its variations and the effects of these upon crops depends, therefore, on the detailed study of profile

sections of a peat basin; they recapitulate, so to speak, the history of its formation. There is a growing recognition of the injustice and the unbusinesslike character of treating all kinds of essentially different peat materials as being equal in quality and cropping value. It requires no argument to show that peat materials are of different composition and have different agricultural and industrial possibilities, but it demands considerable information and investigation to establish these differences scientifically and to show in what manner their agricultural and economic value is not the same. The physical constitution varies greatly according to the locality and topographic features and even in the same field; a recognition of the controlling or modifying factors would emphasize to those using peat land the inherent limitations of the materials. This point is brought out clearly from any series of peat samples obtained in a profile sounding operation.

The lowest layer is frequently a plastic amorphous peat derived in the main from aquatic forms of plant and animal life (diatoms, etc.), and from disintegrating floating organic debris of the marginal vegetation. When the accumulation of this material has reached somewhere a height near the surface water the growth of marginal amphibious plants and following them a floating mat of herbaceous plants is made possible. Gradually this gives rise to a more or less continuous upper stratum of fibrous, felty or matted peat, later covering nearly the entire surface of the basin. The plants of the same association remain together and they become buried at about the same time, as a layer essentially intact. Another change in texture, structure, and composition of materials takes place when after sufficient settling and firmness, the accumulation of peat continues above the water table by the growth of ericaceous and other plants, commonly known as bog xerophytes. This type of peat materials contains, as a layer, woody and leafy components unlike in their resistance to disintegration and dominant among which are certain waxy and resinous bodies. As the conditions which favor more effective weathering, and the action of bacteria and fungi improve in duration as well, they begin to support the growth of coniferous trees, or of a mixed forest, and later a deciduous mesophytic forest vegetation.

The organic debris is then chiefly formed from leaf fall and contains considerable amounts of soluble mineral matter brought to the surface by the activity of the roots of trees. Moreover, the trees and shrubs contribute by their weight to a further sinking of the underlying fibrous mat; and by their shade the displacement of any surface herbaceous and erica-

ceous meadow-forms soon follows. Thus a more woody layer of peat makes its appearance, partly from windfallen timber, which takes on a granular texture as periods of drought and changes in the level of the ground water table permit the disintegrating and weathering processes to reach greater depths. Bearing in mind the great variety of topographic and other field conditions, which bring about fluctuations in the vegetable cover, or in drifted or in windfallen material, it is easily seen that many changes in peat layers and in their intergradations exist, so that it is not always possible to assign a given peat land and the series of its layers to any definite category of causal factors. Hence a careful study of the conditions which exist or may ensue as a result, for example the depth, the number or character of drains, is one of greater importance than appears at first sight.

The main points, however, bearing on crop productivity of peat lands are the following:

- (1) The composition of the horizontal and of the vertical strata of peat materials;
- (2) the degree of disintegration, which is (likewise) dependent on (a) the character of plant associations that contributed to the deposit originally as well as at the present moment, and (b) the duration and effectiveness of drainage, the weathering processes and bacterio-fungal agencies under the existing field conditions;
- (3) the shrinkage of the peat materials in relation to the water table to be established by drainage measures;
- (4) the permeability of the materials for water, air, and roots of crop plants;
- (5) the water content of the surface layer of peat soils when under certain crops.

II. The Influence of Climate.

Varied questions are raised by a consideration of the climatic factor combined with others due to the change in field conditions, in peat materials which partly accompany the sequence of peat forming vegetation, in the influence of weathering or leaching processes, or in the distribution of rainfall and variations in ground water table affecting peat lands.

The annual rainfall in the New England states ranges from 40 to 50 inches, the greater amount of which is precipitated during winter and in the cooler months of spring and autumn. This condition does not compensate for the loss by evaporation during the drier summer season and hence a more or less variable water level exists upon some peat lands lack-

ing barriers than would be possible if the greater precipitation occurred within the warmer season of the year. On the other hand a relatively high and permanent stand of water prevails upon peat lands with natural ridges or with low gradient and where dams have been built or ditches have been neglected. The special climatic conditions under which Massachusetts peat lands have been forming render those with fluctuating changes in the water table and those with subterranean springs in need of more detailed study.

There impresses itself upon the observer a condition in the soil of certain uplands adjoining peat basins, the character of which deserves much thorough investigation. It is strikingly unlike anything observed in regional peat lands of a more continental climate. A typical section taken under a forest cover or one of heath shrubs shows beneath the peaty humus a layer of leached-out, whitish gray sand of varying thickness and underlying it a characteristic yellow to rusty brownish iron-stained sand becoming lighter in color and fading into gray as the depth increases. Where the humus blanket has been denuded for one cause or another these bleached sands support a correlated heath vegetation resembling that of certain peat land areas. The soils appear to be unsuitable for ordinary farming practices.

Not infrequently the proportion of ferruginous constituents is found to be much more considerable along the margins of waterlogged peat lands, while in other cases a bed of bog iron may occur at no great depth below the surface peaty debris. In the central portions of the peat land the iron salts in a precipitated form are as a rule not present. Before deciding on a drainage or utilization project it is important, therefore, to ascertain the location, area and thickness of the ferruginous layers and to determine the chemical nature of the constituents. In origin and formation they are post-glacial, i. e., a relatively recent contamination, and it is of the highest importance that their further development either as black sand, bog iron, or iron pan, should be checked by suitable remedial measures.

It is well known that under waterlogged conditions, disintegrating organic matter and carbonated waters have a marked dissolving power upon minerals of rocks and soils and hence are very potent factors in leaching processes. Leached soils are comparatively poor in mineral plant constituents, especially in lime, potash, and iron salts; leached peat lands are usually acid in reaction, and require therefore fertilizers and the operation of liming or marling to produce the agriculturally desirable qualities of a fertile peat land. The

humid climate of the New England states is very favorable to leaching processes and especially so in the presence of organic matter over porous sandy subsoils. It appears that with the gradual increase in the mass of peat materials, accumulating since the glacial period on uplands and in lowlands areas, widespread changes have been brought about from disintegrating peat by the waters which contained organic colloidal complexes in suspension and moved upward, downward or laterally, according to circumstances through adjoining sandy areas. It is well known that much of the dissolved constituents from the upper soil layer is carried down by the seasonal rainfall and is commonly redeposited some distance below the surface soil, forming the "pan." The upper sand layers are then white or grey in color and very silicious, and where a surface layer of peat or humus is absent, the vegetation becomes more and more open, and dwarfed and heath-like. The land approaches the character of a "barren," since only plants with a shallow root system and with a low requirement of nutrition and growth appear to be able to thrive and mature.

With free drainage at deep levels, pan formation is rarely found. Investigations of European writers have shown how far-reaching is the influence of washing-out or leaching-out of the soluble constituents of the soil in climates of abundant seasonal rainfall. They have pointed out the desirability of avoiding fallows as much as possible, and of keeping the soil well occupied by crops, particularly hay and pasture grasses, certain staple crops, and root crops.

In the cases where seepage and ground water are not carried away by free drainage, the leached materials tend to accumulate in the soil and to cement the sandy substrata. During the drier season of the year the downward movement of water ceases; the ground waters from the lower layers begin to move upward, and the soluble materials have then an upward tendency.

Periods of drought, strong winds, and consequent evaporation favor absorption and the deposition and concentration of iron and other salts in solution. The loss of any excess of carbonic acid from the underground waters, the presence of alkaline earth, or a substratum richer in soluble salts; the increased oxidation in the stratum on being exposed to the atmosphere, and the destruction of the colloidal humus complexes, which is partly accomplished by the action of bacteria,—any one or all of these factors may liberate the iron, alumina, magnesia, and others. These may form under certain conditions either nodules or concretions in the soil, or in

some cases a continuous layer of considerable thickness. The solid aggregations vary widely in composition, in amount of fine-grained organic matter and in degree of cementation. Hence much importance should be attached to the character and color of peaty waters, the amount of suspended material which they contain, to the direction of their transport and movement as percolating ground waters, and to the place of ulterior evaporation of these waters, e. i., the precipitation of their salts. It is needless to add that to the form of the surface drainage channels on the horizontal, vertical or lateral movement of such ground waters on peat land the greatest of care should be given.

Observations on peat lands with a water level 30 to 40 inches below the surface and which are not exposed to floods show that evaporation is relatively active during the summer season. This renders the surface soil when under cultivation liable to saline incrustations due to salt constituents of various kinds in solution drawn from the deeper beds. The action is strongly marked in ditches on peat lands with a water table fluctuating during the seasons for plant growth.

In deep and broad peat basins the imbibition and transport of soil waters is on the whole horizontal and dependent for its position upon those strata of peat materials whose composition and properties favor a lateral movement. This is readily observed in open ditches with peaty strata which permit underground water drainage along the cleavage lines and (upon estuarine peat land) which contain beds of diatomaceous earth or heavy layers of ash owing to severe and extensive clearing fires. The ash is chalk-like in color at the inner portions of the peat basin due to the removal of iron compounds to which the yellow and red ash at the marginal areas normally owes its color.

In shallow peat lands and those of small size and depth the transport of ground waters appears to be vertical and lateral. During floods, however, the abundance of water reduces the movement of the saline constituents and from the appearance of the characteristically bleached sands underlying the peat lands it may be concluded that the transport is then lateral and downward where under-drainage is free.

We are lacking data showing the increase in evaporation and vertical salt deposition due to specific crops, such as corn, potato, certain truck crops, and grasses for hay or pasture, but there is little doubt that onion would show an excess.

Fogs and other forms of humidity should be closely observed since it may be regarded as probable that a considerably larger number of days with a water vapor blanket reduc-

ing low temperature in the critical frosty days of the growing period may result from the enhanced evaporation conditions consequent to the increase in cultivation. This may make the relative humidity conditions and therefore the duration of the growing period for crops more advantageous in certain localities with peat lands of greater depth of materials. But this question and others connected more chiefly with physiological effects of field conditions on crop plants demand a more thorough study than has been at present accorded to peat investigations.

III. The Geological and Topographic Factors.

Owing to the solvent action of disintegrating masses of vegetable material a consideration of the underlying rocks and soils has therefore great importance practically as well as theoretically, because they are in many respects the causes of the more primary differences between marly alkaline to neutral peat lands and ferruginous and acid peat lands; they determine also in a great measure the degree of disintegration, leaching, and weathering of peat, and they condition the particular drainage measure, the choice of the crop system, and the cultural methods best suited to their respective peat materials.

According to the relief of the land Massachusetts may be divided into a number of physiographic provinces, each marked by its own characteristic topography and geologic belts.

In the western section of the state are the series of mountainous ridges of rugged topography, the rocks of which consist of strongly folded and faulted quartzites, limestones, slates, schists, etc., mostly of Paleozoic age. Of primary consideration is the fact that in the Berkshire Valley the peat lands of morainal lacustrine and of valley topography are generally underlaid by marl and similar calcareous substances.

The Connecticut Valley is marked in general by the presence of soft reddish Triassic sandstones and shales, with an occasional trap ridge. East of it in the highlands occurs a belt of folded sedimentary and metamorphic rocks and further eastward, gradually sloping toward the coast, is a broad crystalline belt consisting largely of metamorphic and igneous rocks, such as granites, micaceous gneisses and others, both basic and acid, but including many altered sedimentary beds. In the vicinity of Boston and southward there are considerable areas of carboniferous sandstones, conglomerates, and slates.

The mantle of drift or till left by the glaciers masks and obscures the pre-glacial peneplain. The most characteristic forms of the glacial soils are the rounded hills of unmodified

material known as drumlins, which show a tendency to linear grouping. The peat lands in their depressions are conditioned in the main by springs; but unlike those located along fault lines and issuing from rock crevices, the springs are intermittent and show their connection with the seasonal rainfall.

Another form of glacial drift are the plains of stratified sand which appear to be chiefly deltas and outwash aprons formed by streams during the successive stages of lowering of ancient glacial lakes. These sand plains may be regarded as the natural reservoirs of characteristically soft water, with a uniformly shallow water table. Peat lands occupying depressions in the stratified drift are well exemplified by the "Great Cedar Swamps," so abundant in the southeastern portion of the state. The great extent and the continuity of these sand plains has been one of the chief causes in the obstruction of former drainage channels and in the formation of those lake and river peat lands which today constitute the main peat resource of the state.

The till of the upland adjoining peat land is arenaceous, porous in texture, and supplemented with occasional interbedded and superficial layers of washed material. It readily absorbs the greater portion of the rainfall and is quite susceptible to the "podsoling" process mentioned above. Differences in this feature may be accounted for in part by the variations in the surface organic materials, in the texture and character of sub-surface mineral soils, and in the season's rainfall from year to year.

The till underlying the peat lands is prevailingly well compacted and probably is the principal source of supply as well as the factor determining the nature of the ground waters.

Beds of clay underneath peat lands are not numerous; they are found deposited at relatively low levels of elevation, and to some extent under the salt marshes and in the fresh water peat lands near the coast.

The rock formations and soils in the respective water sheds of the state and at the head of the main rivers arising there, are probably of no less importance in supplying the dominant mineral constituents of springs and groundwaters than the soils underlying the peat lands in the coastal plain section. The variations in organic materials of estuarine peat lands and the amounts of their inorganic impurities depend undoubtedly much upon the individual streams, their varying currents, flooding power, and the specific nature of the organic and mineral constituents carried in suspension. Consequently analytical work would naturally be of deep interest to those

favoring the chemical side of the question in its relation to problems of fertilizer requirement in the improvement of peat lands.

However, it is still an open question whether the conditions are ripe for the closer chemical investigation which many soil students desire, except in those more extreme and primary distinctions between calcareous and ferruginous peat lands. Whether the chemical method would yield the results in any way as definitely correlated with the tilling qualities of peat lands and their agricultural or industrial value, as for example, ecological or bacteriological investigations, is a problem which warrants further investigation.

The main questions from the geological standpoint, which seem to require careful consideration, are:

(1) the character and the condition of the underlying rocks and mineral soils;

(2) the variations in and the nature of the ground waters at the various levels of the peat mass;

(3) the direction and the distribution of the salts during transport, especially along the lines of cleavage in the stratal ground water drainage, and their place of deposition.

IV. Some of the Uses of Massachusetts Peat Lands.

There is today generally a greater interest in and a better appreciation of the advantages which peat land has over soils of other kinds in regard to cost of labor, ease of tillage, range, yield, and market of crops. Some of the factors for which the farmer is personally responsible and on which the permanent improvement of these soils largely depends, have been described elsewhere (*Journ. Am. Peat Soc.* 9, 10-21, 1915). There is need of emphasizing in this connection that much consideration should be given to the dangers from over-drainage and improper cultural methods.

As to fertilizer, either potash, principally the basic form, or manure should be used to begin the improvement of peat lands, but liming may or may not be advisable. The acidity of certain peat materials does not necessarily decrease their productivity. The only correct means, however, of determining the fertilizer requirements on peat land of specifically different peat materials consists in making actual growing tests and studying the reactions and the yields obtained. The use of manure is to be highly recommended, especially upon the heavy, compact phases of peat, which should receive the coarser manures. The value of fibrous peat material as a stable litter or bedding in stock and in dairy farming can hardly be over-estimated. Peat materials are known to absorb not only large quantities of water or of solutes but gaseous

products as well. Owing to their great absorptive power peat materials are used as a deodorizer and as an efficient absorbent for gaseous ammonia formed from the decay of manure, which would otherwise escape into the air and be lost.

There is little doubt that the agricultural development of suitably prepared peat lands in Massachusetts would prove to be profitable. The cultivation of grasses and certain clovers for hay and pasture for a few years will probably be the safest operation. The pasture problem has been in the main neglected and hence it seems that it should be relatively advantageous to double the product. Moreover, the decrease in the number of head of livestock has been very great in all countries of late and a strong demand for both animals and their food is making itself felt.

But the peat lands of Massachusetts may well be utilized for other types of farming. Every effort should be made to eliminate this waste of peat land resources and to increase the food products of the state. Corn, preferably for silage purposes, potato, oats, rye, and clovers with grasses may be grown; they should be rotated every few years. Root crops to supplement pasture and used as succulent feed for stock in fall and winter on the farm would not only improve the plowed layer, but probably give fairly high yields. They should follow cereals such as rye, oats, millet, and others. This list is not a large one, but that is mainly due to the fact that carefully conducted field trials to serve as practical demonstrations are quite essential in a state with peat lands differing in field conditions. Detailed investigations on crops with qualities of resistance, of rapidity in growth and maturity, capacity to yield suitable variations and related to specific peat materials and field conditions are still lacking from which to obtain reliable information. No less important is the greater utilization of peat lands for certain ornamental trees and shrubs and for much of the nursery stock and also for many bulb plants which are now imported from other countries with the dangers of disease infection. The peat lands of Massachusetts certainly compare favorably with those which have been so successfully utilized in Sweden, Holland, Germany, and other countries of northern Europe.

The use of peat materials for industrial purposes is constantly increasing; their place and role as stock food ingredient; their value as fertilizer dilutent or filler both with and without previous treatment or mixture with inorganic salts; their effectiveness as a carrier of bacterial inoculations; as fiber for surgical dressings, for special grades of paper, for carpets or for packing material; their value as granular, com-

pressed or powdered peat; in the manufacture of producer gas and heating devices; the use of sapropel and ericoid materials for the distillation of tar and related products, for purposes of extraction of crude oil, ammonium sulfate, paraffin, wax or fuel gases; their effectiveness for hygienic and sanitary purposes such as peat baths and mud baths; for these and other uses peat materials are assuming considerable prominence commercially (see Bull. 16; Chapter IV, Ohio Geological Survey, 1912). It involves a knowledge of the peat materials and the removal and destruction of specifically suitable beds or strata, and therefore should be resorted to only in exceptional cases after detailed technical information has been secured. Of fundamental significance is the method of collecting the materials; this should not be done without reference to the fact that the layers of peat materials in a deposit are different in origin, composition, and properties, and in not a few instances may be entirely unsuitable for the specific uses referred to above. The economic utilization of peat materials, by far much more so than their agricultural usage, must base itself upon a knowledge of the different kinds of peat materials and the factors in the field which conditioned their accumulation and character; hence their technical use should be treated as a rather highly specialized form of business, if the best financial results are to be obtained.

Considerable attention has been drawn of late to statements that an important and valuable effect of peat is in its value as a plant food,—i. e., in the presence of certain "accessory" organic food substances derived from bacterized peat material; very small amounts of it are thought to be sufficient to satisfy the needs of growing plants. This subject has been under investigation in Germany and in England. The action of these compounds, as yet undetermined chemically, is reported to have been variable. This no doubt may be due to the difference in character and in the conditions of the peat materials used in relation to the efficiency and the duration of action of beneficial micro-organisms. To bacteriologists the action of bacteria and fungi in converting certain organic and inorganic substances into a soluble form and to bind free atmospheric nitrogen is not a new problem. It is rather in the technical handicap of using peat materials as carriers which are free from objectionable qualities and in the development of satisfactory methods to maintain an active state of condition in the organisms yielding the requisite products.

If Massachusetts continues to forge to the front as she has done in her cranberry industry, it will be through a recognition of the differences existing in field conditions of peat

lands and in peat materials affected by them. This work may take much effort, but it can be accomplished through the state agencies now at work.

Conclusion.

The reconnaissance work on Massachusetts peat lands leads to the following general conclusions:

1. The inequality in the character of peat lands encountered and in the strata of their materials may render a more detailed study one of considerable advantage in their agricultural or industrial utilization and requirements.

2. It would be of special advantage should specific peat materials and field conditions be kept under observation where underdrainage is intended and where changes are being made in the groundwater table, so that the agricultural development may correspond with the existing field conditions and with the ensuing changes in the character of the peat materials.

3. Information concerning the seasonal variations in the water table, the nature of the salt constituents, and the circumstances in the field conditions which lead to the augmentation or diminution of soluble constituents is of prime importance, the effect of any accumulation of iron compounds especially requiring attention in certain cases.

4. The relation of cropping system to the several kinds of peat lands if ignored would be to the disadvantage of the real agricultural value of certain peat lands. Field trials are the more correct means under the existing conditions on the peat lands to determine the choice of crop varieties, seeding mixtures, etc., and the cultural practices to be followed.

THE PEAT DEPOSITS OF THE UNITED STATES.*

United States Geological Survey Suggests Use of Peat as Substitute for Coal and Other Minerals.

(By C. C. Osborn.)

According to the United States Geological Survey, Department of the Interior, the commercial development of the vast peat deposits in the United States would materially relieve our present shortage of fuel. Although peat has never been largely used as fuel in this country because of our abundant supply of coal, which can be more readily prepared for consumption and in normal times more cheaply brought to the consumer, it has long been used in Europe, where 15,000,-000 to 20,000,000 tons are consumed annually in generating heat and power.

The attempts made in this country to manufacture peat fuel on a commercial scale have not been successful, but the failure appears to have been due not to a lack of market for the product but to the lack of sufficient capital, to the inexperience of the operators, and to preventable engineering errors. It is said that air-dried machine peat, which is but little inferior in calorific value to many grades of lignite coal, can be produced at a cost ranging from 75 cents to \$2.50 a ton, the exact figure depending on the size and the efficiency of the plant; and it is believed that in some parts of the country it could successfully compete with other fuels for both domestic and industrial use. It burns with little smoke and ash, and wherever it has been used in this country it has proved very satisfactory and has found ready sale as fast as it has been produced.

The wide interest felt in the larger use of peat in the United States is expressed in recent messages from the governors of Maine and Massachusetts to the legislatures of those States, recommending an investigation of the local deposits of peat and its possible use to relieve the present shortage of fuel.

The lack of other fuel in many European countries is now being supplied in part by an increased use of peat. According to United States Commerce reports 216 peat machines were in operation in Norway in 1917, compared with 55 in 1916 and 36 in 1914. Among these were two automatic machines, each costing \$13,400, having a daily capacity of 30 to 40 tons of fuel, and requiring only two men for its operation.

Peat consumed in a properly designed gas producer yields

*Prepared for the press by the U. S. Geological Survey, Mar. 14, 1918.

gas of good quality and in abundant quantity in comparison with the yield from coal, as well as many valuable by-products. This is perhaps the most effective utilization of peat fuel for generating heat and power, because peat that is to be used in this way does not need to be so carefully prepared nor so thoroughly dried as peat that is to be consumed under steam boilers.

Specific information with regard to the use of peat in gas-producing plants and for other purposes is given in a bulletin prepared under the supervision of the United States Geological Survey but published as Bulletin 16 of the Bureau of Mines, from which copies of it may be obtained.

Nature and Distribution of Peat Deposits.

Peat is a dark-brown or black residuum produced by the partial decomposition of mosses, sedges, and other vegetable matter in marshes and like wet places. Most of the peat deposits of this country occur in depressions and poorly drained areas in regions where the temperature of the air and the soil is low in summer and the humidity of the air is high. The most extensive peat beds are found in New England and around the Great Lakes, where the climate and the topography are favorable to the accumulation of partly decomposed vegetable matter. Many deposits are found also in the Atlantic Coastal Plain, from New Jersey southward to Florida. In regions of heavy rainfall along the Pacific coast peat bogs occur wherever the drainage is so greatly interrupted that the soil becomes permanently saturated with water.

The Second Annual Report of the Public Utilities Commission of Maine contains descriptions of many peat bogs in that State. Detailed information relating to the occurrence of this material in Maine and a map showing the location of workable deposits in that State can also be found in United States Geological Survey Bulletin 376, which, though no longer available for free distribution, may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 20 cents a copy.

It is estimated that more than 11,000 square miles of swamp land in the United States contains peat beds of good quality, and that the total available fuel in these deposits would amount to more than 12,000,000,000 tons, a quantity that, if it could be distributed, would furnish heat and power for the entire country for many years. Much of this material is in States that have no known deposits of coal and that on account of their cold climate and their manufacturing industries consume large quantities of fuel, a constantly increasing

percentage of which has to be brought by rail and water from distant mines. According to a recent estimate made by Prof. E. K. Soper in a paper on the peat deposits of Minnesota, published by the Minnesota Geological Survey, more than 6,000,000,000 tons of air-dried peat fuel can be obtained from deposits in that State alone. The utilization of these deposits would augment the local fuel supply and incidently would relieve the strain on our transportation facilities by furnishing fuel to an area where coal is now brought by the longest haul.

Antiseptic Value of Peat.

Peat produced by the decomposition of sphagnum moss is so antiseptic and absorbent that it is used as a dressing for wounds and is an excellent substitute for medicated cotton. This fact was recognized many years ago in Europe, where sphagnum peat is now extensively used in preparing surgical dressings. According to Prof. Soper, who has made a detailed study of the peat deposits in northern United States, there are many square miles of sphagnum bog in the northern counties of Minnesota, Wisconsin and Michigan that would supply material suitable for antiseptic applications. It will not be necessary to incur the expense of deep excavation, for immense quantities of sphagnum can be taken from the upper parts of the deposits. Sphagnum peat is also abundant in Maine, and some is found in New York and northeastern Pennsylvania.

Uses of Peat in Agriculture.

The increased use of peat and its products in compounding fertilizers may also afford relief from the present shortage of fertilizing minerals in the United States. Peat has long been used in agriculture in this country, having been either applied directly to the land or used as a filler for commercial fertilizers. In view of the curtailment of the imports of potash and nitrates since the war began and the consequent shortage of fertilizers the time has come when the producers of peat might make better known its value in agriculture.

Analyses of the peats of the United States show that they are very rich in combined nitrogen, from 70 to 85 per cent of which, a proportion that in some peats amounts to more than 2 per cent of their dry weight, may be recovered in the form of ammonium sulphate, one of the costly ingredients of modern commercial fertilizers. Peat may also be a source of nitrates. A culture bed of peat, if treated with a dilute solution of ammonium sulphate and then inoculated with nitrifying organisms, is said to yield 0.82 per cent of nitrates, and with repeated treatment about 4 per cent. It has not yet been

shown that this process will produce nitrates on a large scale, but in view of the rare occurrence and present shortage of these salts, which are so essential to agriculture and to the explosives industry, the process strongly invites further and larger experiments.

Peat mull may be profitably employed as an absorbent of the valuable nitrogenous liquids of stables, which are ordinarily wasted. When so used it not only absorbs liquids but checks decomposition and absorbs gases, so that it should be an effective deodorizer and disinfectant. For this use it is superior to lime, ashes, and some of the more expensive disinfectants, and it is a nearly ideal material for use in earth closets and other receptacles for moist waste organic matter.

Peat has also been used successfully in this country as bedding for stock and in compounding stock feed.

Other Industrial Products of Peat.

Peat has frequently been used as a source of charcoal and coke, of various by-products from coke retorts, such as those obtained from the distillation of wood and of fuel and illuminating gas, as well as in making paper, substitutes for wood, and packing material. The prospective value of the peat deposits of the country as a source of these products is much larger than their value as a source of fuel.

Information with regard to the occurrence, distribution, and production of peat in the United States will be furnished on application to the United States Geological Survey, Interior Department, Washington, D. C., and information on the use of peat for fuel and other purposes may be procured from the Bureau of Mines, Interior Department, Washington, D. C.

PEAT OCCURRENCES

Washington County, Alabama.

Muck, as mapped in Washington County, includes swamp-like areas of black or dark-brown soil composed of partly decomposed organic matter and varying proportions of mineral material. These areas are generally referred to locally as "made land." The depth of these deposits is variable, ranging from a few inches near the edge to 3 feet or more in the center of the areas. The underlying material is for the most part a black to bluish-black, stiff, heavy clay. In places the decomposing vegetable matter is fibrous and contains little soil material, thus having the characteristics of peat.

The muck land at present is not cultivated, but formerly part of these areas was cleared and cultivated to corn and rice. The yields at first are said to have been heavy, but they decreased and the project was abandoned. This soil now supports a second growth of pine and gum trees and underbrush.

The muck land, in general, has a low value locally for agriculture. Where the land is near a market or shipping point it might be profitably worked by draining it and raising such crops as celery, onions, and cabbage. Muck generally is classed with the swamp lands, as small patches occur throughout all the swampy areas along the creeks and branches.

(From Soil Survey of Washington County, Ala.)

Peat in Lake County, Illinois.

Deep Peat.—Deep peat is found in nearly all parts of Lake County, Illinois, occurring on the old beach of Lake Michigan, in the bottom lands of the streams, in the depressions of the moraines, and around the margins of many of the lakes. The total area is 38.1 square miles, 24,382 acres, or 7.89 per cent of the area of the county. The deep peat is formed by the growth of both grasses and mosses. In one area in section 35, T. 46, N. R. 10 E., the peat was found to be forming entirely by the accumulation of the sphagnum moss, independent of the growth of grasses; in other areas, both grasses and mosses contribute to the deposit.

The surface soil, 0 to 6 2-3 inches, is black or brown peat, more or less decomposed. The drained areas have undergone greater decomposition because of better aeration, whereas the moss-covered or grass-covered peat of the undrained areas has changed but little. The content of organic matter varies from 61 to 77 per cent, with an average of 70.5 per cent.

The subsurface soil, 6 2-3 to 20 inches, consists of black or brown peat that usually shows the texture of the material from which it was produced.

The subsoil, 20 to 40 inches, is usually brown peat, although in some small areas sand or silty material may form the subsoil below 30 inches. This latter phase is almost invariably drab in color, from deoxidation by organic acids.

Because of lack of drainage, this type of soil in Lake county has not been largely cultivated, except in the small areas. It does, however, supply a large amount of hay that is used to a considerable extent for packing ice in the large ice houses on the shores of the lakes. As a rule, it is not desirable to attempt to drain this type of soil by means of tile unless the tile can be laid deep enough to be in the clayey or silty subsoil. Tile laid in peat soon get out of line.

As shown in Table 1, deep peat contains in one million pounds of surface soil about 32,000 pounds of nitrogen, 1,500 pounds of phosphorus, and 3,900 pounds of potassium. This shows in the surface 6 2-3 inches of an acre nearly five times as much nitrogen as the brown silt loam prairie soil. In phosphorus content these two soil types are about equal, but the peat contains less than one-tenth as much potassium as the brown silt loam. Thus the total supply of potassium in an acre of the peat to a depth of 7 inches (3,900 pounds) would be equivalent to the potassium requirement (73 pounds) of a 100-bushel crop of corn for only 53 years; or if the equivalent of only one-fourth of one per cent of this is annually available, in accordance with the rough estimate suggested in Bulletin 123 of the Illinois Agricultural Experiment Station, then about 10 pounds of potassium would be liberated annually, or sufficient for about 14 bushels of corn per acre.

TABLE 1.—Fertility in the Peat Soils of Lake County, Illinois.

[Average pounds per acre in two million pounds of surface soil (about 0 to $6\frac{2}{3}$ inches thick.)]

Soil Type.	Total Organic Carbon	Total Nitrogen	Total Phosphorus	Total Potassium	Total Magnesium	Total Calcium	Lime-stone Present	Soil Acidity
Deep peat (slightly decomposed moss)	445,080	7,900	670	6,120	3,360	2,850	.....	8,380
Deep peat, normal phase	398,040	42,570	1,540	3,900	6,260	24,970	.....	140
Medium peat on clay	206,230	17,330	1,240	16,450	9,140	18,450	.....	50
Medium peat on sand	271,560	18,450	1,080	12,420	8,080	18,860	.....	80
Shallow peat on clay	380,800	27,420	1,110	6,410	6,310	28,780	.....	290
Peaty loam	334,170	31,650	2,300	18,540	13,410	40,050	Often	.....

In Table 2 are given all results obtained from the tests at the Manito (Mason County) experiment field on deep peat, which were begun in 1902 and discontinued after 1905. The plots in this field were one acre* each in size, and were 2 rods wide and 80 rods long. Untreated half-rod division strips were left between the plots; these strips, however, were cropped the same as the plots.

The results of four years' tests, given in Table 2, are in complete harmony with the information furnished by the chemical composition of peat soil as compared with that of ordinary normal soils. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainite and potassium chloride were applied, slightly greater yields were obtained with the potassium chloride, which, however, supplied about one-third more potassium than the kainite. On the other hand, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chloride (common salt) produced no appreciable increase over the best untreated plots, indicating that where the soil is deficient in potassium itself, salts of other elements can not take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainite, in either the first year or the second.

* In 1904 the yields were taken from quarter-acre plots because of severe insect injury on the other parts of the field.

TABLE 2.—Corn Yields in Soil Experiments Yield; Typical Deep Peat Soil.
[Bushels per acre.]

Plot No.	Soil treatment for 1902.	Corn 1902. • 1903.	Soil treatment for 1904.	Corn 1914.	Corn 1905.	Four Crops
1.	None	10.9	8.1	None	17.0	12.0
2.	None	10.4	10.4	Limestone, 4,000 lbs.	12.0	10.1
3.	Kainite, 600 lbs.	30.4	32.4	{ Limestone, 4,000 lbs. Kainite, 1,200 lbs.	49.6	159.7
4.	{ Kainite, 600 lbs. Acidulated bone, 350 lbs.	30.3	33.3	{ Kainite, 1,200 lbs. Steamed bone, 395 lbs.	53.5	164.7
5.	Potassium chloride, 200 lbs.	31.2	33.9	Potassium chloride, 400 lbs.	48.5	52.7
6.	Sodium chloride, 700 lbs.	11.1	13.1	None	24.0	22.1
7.	Sodium chloride, 700 lbs.	13.3	14.5	Kainite, 1,200 lbs.	44.5	47.3
8.	Kainite, 600 lbs.	36.8	37.7	Kainite, 600 lbs.	44.0	46.0
9.	Kainite, 300 lbs.	26.4	25.1	Kainite, 300 lbs.	41.5	32.9
10.	None	14.91	14.9	None	26.0	13.6
				Estimated from 1903; no yield was taken in 1902, because of a misunderstanding.		69.4

Reducing the application of kainite from 600 to 360 pounds for each two-year period, reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainite (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

Medium Peat on Clay.—Medium peat on clay occurs in low, swampy areas, where the peat has not developed to a greater thickness than 30 inches. The total area is 640 acres, equivalent to 1 square mile, or 0.21 per cent of the area of the county.

The surface soil, 0 to 6 2-3 inches, is a brown or black peat, the decomposition varying with cultivation and drainage.

The subsurface soil, ranging from 6 2-3 inches to the depth of the peat, is usually a brownish peat that has not undergone much decomposition. In the classification used by this station, medium peat extends 12 to 30 inches in depth, and in most areas the subsurface is usually taken as extending to the silty, clayey, or sandy layer. This gives a large variation in the thickness of the subsurface, but it is sampled to a depth of 20 inches.

The subsoil in this type consists of a silty clay and is almost invariably of light drab or bluish color, owing to deoxidation of iron by organic acids.

The treatment advised for this type is the same as for deep peat, but thorough trials should be made with potassium in advance of extensive use. Drainage is an easier matter because tile may usually be placed in the clay.

Medium Peat on Sand.—Medium peat on sand is found only on the old beach of Lake Michigan, north of Waukegan, and there only limited areas are large enough to map. The total area is 284 acres.

The surface soil, 0 to 6 2-3 inches, is a brownish, somewhat decomposed peat mixed with more or less sand.

The subsurface soil extends to a depth of 12 to 20 inches, passing into a drab-colored sand that continues to an indefinite depth. Practically no land of this type is under cultivation, although some of it is used for pasture. Potassium is the only material suggested for trial applications.

Shallow Peat on Clay.—Shallow peat on clay occurs in small areas on the upland and is usually not very uniform. The total area is 371 acres.

The surface soil, 0 to 6 2-3 inches, consists of a dark, peaty material mixed with more or less sand, silt, or clay. It varies from pure peat to a very black silt or clay loam. Very few of the areas are under cultivation, but are mostly in pasture. The tramping of cattle has produced hummocks, which vary in height from 4 to 12 inches.

The subsurface soil is usually a brown silt loam, changing into a drab or bluish color at 12 to 16 inches in depth.

The subsoil is mottled drab or yellow and usually contains some fragments of limestone. Alkali patches are of frequent occurrence.

The first requirement of this type is good drainage. Where the surface is deficient in potassium, deeper plowing will bring an abundance of it from the subsurface to be incorporated with the plowed soil.

Peaty Loam.—Peaty loam is found in small areas in the depressions on the high terrace of Lake Michigan in the northeast part of the county. There is also one larger area in a broad valley west of Lake Bluff. The total area is not large, amounting to only 2.35 square miles, or 0.49 per cent of the area of the county.

The surface soil, 0 to 6 2-3 inches, is a black, peaty loam. The amount of organic matter and sand varies in different areas, the content of organic matter ranging from 10 to 25 per cent, or even more than 25 per cent.

The subsurface soil is quite variable. In some areas it is a drab or bluish sand mixed with a variable amount of organic matter; in other places it is a brown sandy loam; and in still other places it is clayey or silty.

The subsoil varies from a sand to a sand containing a considerable amount of silt and clay.

The first requirement of this type is good drainage. Some areas may require the application of potassium in order to produce good crops. This is especially true of those areas where the soil contains little or no clay. Alkali is frequently present in sufficient quantities to be very harmful to crops, particularly corn. The alkali consists chiefly of harmless carbonate (limestone) with smaller amounts of injurious magnesium carbonate.

In some places these peaty soils actually contain a good percentage of total potassium, more commonly in the subsurface or subsoil but sometimes in the surface soil also, and yet the untreated soil may be unproductive, whereas the addition of potassium salts may produce large and profitable increases in the yield of corn, oats and other crops. In pot-culture experiments the Illinois Station have been able by the

addition of potassium sulphate to correct to a considerable extent the injurious property of magnesium carbonate that has been purposely applied to ordinary brown silt loam prairie soil known to contain an abundance of available potassium. These facts are mentioned here because the Experiment Station recommends, tentatively, the application of potassium salt to all classes of peaty and alkali soils that are unproductive after being well drained, whenever the supply of farm manure is insufficient. It should be understood that plenty of farm manure, preferably quick acting or readily decomposed manure, such as horse manure, will supply potassium and thus accomplish everything that potassium salts can accomplish; on some swamp soils manure produces good results even where potassium is without effect.

BENTON COUNTY, INDIANA.

The muck is composed of decayed and decaying vegetable matter mixed with a small quantity of mineral matter washed in from the adjoining higher-lying soils. The surface material is very black and is characteristically loose and fluffy when dry. This material is underlain by brown fibrous peaty material which in turn rests upon a brown or yellowish-brown, light-textured loam. Occasionally the lower subsoil is a yellow to drab silt loam or clay.

The muck occupies slight depressions. The depth of the chiefly organic material varies from a few inches in the small areas to over 3 feet in the larger bodies. As mapped, the Clyde silty clay loam includes a few small areas of shallow muck or chaffy land.

The natural drainage is very poor, and tiling and ditching have been resorted to in order that crops may be grown. Muck is an unimportant soil in Benton County, as its total area is very small. It is confined to a few areas in the northern and eastern parts of the county. Some of it is planted to corn, which gives good yields if not injured by early frosts, and the remainder is used as pasture. Bluegrass does well.

Celery, onions, lettuce, and cabbage might profitably be grown on the muck areas for local markets. A complete fertilizer mixture, with 4 per cent nitrogen, 8 per cent phosphoric acid, and 10 per cent potash is generally used on muck soils, potash providing the most effective element. Applications of ground limestone are often necessary to correct acidity.

(From Soil Survey of Benton County, Indiana.)

SCOTT COUNTY, IOWA.

Areas in which the soil material, to a depth of 18 inches or more, consists mainly of decomposed vegetable matter are

mapped as muck. The soil is black and is usually underlain to a depth of more than 3 feet by a drab or gray and yellow mottled silty clay. When dry, the surface soil has a loose, friable, flaky structure, but when wet it is spongy.

Several small areas have been mapped in the northern part of the county. There is also a small tract near Davenport, in the northeastern part. The type occupies depressed areas where conditions have been favorable for the accumulation and partial decomposition of organic matter. The surface drainage is very poor, and the soil is saturated during a large part of the year. Muck is of little importance in Scott County. None of it has been drained, and over most of it conditions are unfavorable for the establishment of drainage without great expense. It supports a luxuriant growth of water-loving grasses and is utilized for pasture.

With proper drainage and cultural methods this muck is well adapted to the production of corn, onions, and celery.

(From Soil Survey of Scott Co., Iowa.)

SOUTHERN PART OF NORTH-CENTRAL WISCONSIN.

The soil survey of the southern part of north-central Wisconsin embraces four counties, Taylor, Lincoln, Clark, and Marathon.

The material mapped as peat consists of vegetable matter in various stages of decomposition. Much of the material is still in a very raw, fibrous condition, showing plainly the structure of the vegetable growth from which it is derived. In a fibrous condition the material is brown, but with decomposition its color becomes darker, and where thoroughly decayed it is black or very dark brown. Mineral matter may be incorporated with the organic matter, but seldom in sufficient quantity appreciably to affect the texture. In the more extensive areas of peat there is little or no mineral matter except about the margins, where the proportion is frequently sufficient to form muck. The muck areas, however, are too small to be satisfactorily separated, and are included with the peat.

The depth of the peat is variable. The areas in which it is less than 18 inches thick are classed as shallow-phase. In some places the organic deposits are more than 20 feet deep, and in practically all the swamps having an area of 1 square mile or more the depth is more than 3 feet. The peat is generally thickest in the center of the deposit, and shallowest about the margins.

In the large swamps and marshes where the material is still raw there is very little difference in character between the surface material and the material several feet below the surface. Where conditions have favored rapid decomposition

the material at the surface frequently is considerably darker than that at lower depths. A profile section may consist of 8 to 16 inches of black, fairly well decomposed organic matter, underlain by brown or light-brown, raw, fibrous material extending to depths of 3 to 20 feet.

The material underlying the peaty matter is variable, and ranges from sand to silt loam or clay loam. In general, its texture is determined largely by that of the surrounding upland soil. In the regions of silt loam soils the underlying material is unusually heavy and of a light-gray or bluish color. Throughout the sandy sections in practically every instance the peaty material is underlain with grayish or nearly white, fine to medium fine sand, and in some instances considerable gravel is mixed with the sand.

Areas of peat are distributed through all the counties of the survey, but are most extensive in the glaciated regions of southeastern Marathon County, northern, central and southwestern Lincoln County, and northern Taylor County. In the region referred to as unglaciated there are very extensive tracts in which no peat occurs. The most extensive areas of peat are mapped northeast of Hannibal and 7 to 12 miles west of Dancy, along the Little Eau Pleine River. In Clark County large areas lie in the southern and western parts.

Practically all the peat areas are level, or have only a very gentle slope. The slope is nowhere sufficient to drain the material without the use of open ditches. Most of the areas of peat are wet the greater part of the year, and in the spring, when heavy rains occur, the surface is often covered with a few inches of water. A large number of the marshes in which peat occurs, probably representing the greater part of the peat as mapped, have sufficient slope to be successfully drained. Along the Little Eau Pleine River a drainage district has been established to reclaim a large tract of marsh land, and other extensive drainage projects are being developed, but the total area of peat actually producing crops is very small.

The native trees of the peat areas are chiefly tamarack, cedar and spruce. Some of the marshes have no trees or only a scattered growth of spruce or tamarack. In most of these places the original timber has been destroyed by fire, though a few marshes apparently have always been treeless. On some of the open marshes coarse grass grows, which is cut for hay, but in most places the vegetation consists of sphagnum moss, cranberry bushes, and other moisture-loving plants.

The peat is underlain with sandstone or crystalline rocks

and the surrounding upland soils are entirely of noncalcareous material. Practically all the peat is acid.

More land is under cultivation in the southern part of the area surveyed than in the northern part, hence the peat lands in the southern section will probably be reclaimed first. The first requisite is thorough drainage, and the large marshes can best be developed through the land owners' cooperation in establishing drainage districts. The peat is very high in organic matter and nitrogen, but is low in potash and phosphoric acid, and the application of commercial fertilizers containing these elements is beneficial. Where thorough drainage is established and proper methods of cultivation are followed this kind of land is adapted to the production of various crops, including corn, potatoes, cabbage, buckwheat, and timothy and alsike clover. Where the soil is made firm by rolling, small grains can be grown. Good pastures of tame grass can be established on this land.

The peaty material itself can be applied advantageously to sandy soils. Where peat bogs adjoin sandy land that is being farmed it is a good practice to apply peat in the same manner as stable manure, supplying mineral elements in the form of commercial fertilizer.

Peat, shallow phase: The shallow-phase peat is differentiated from the typical soil solely on the basis of the thickness of the peaty deposit, the maximum thickness of the shallow phase being 18 inches. The underlying material is variable. In regions where the upland soils are heavy the subsoil is usually silt loam or clay loam, rather strongly mottled. Where the uplands are sandy the subsoil is usually light, consisting of sand or sandy loam, and in some places fine sand. The depth of the peaty material varies from 6 or 8 inches to 18 inches. In Clark County this phase includes a few low, sandy islands which are too small to be shown on the soil map.

The areas of shallow-phase peat are most extensive in the southern parts of Marathon and Clark Counties. Also, there are scattered areas in the eastern half of Marathon County, and a few small areas in other parts of the survey.

Wild hay is about the only crop gained from this soil at present. It is used to a small extent for grazing. In its present condition it has a low agricultural value. When drained it will be adapted to the same crops and types of farming as typical peat soil.

(Soil Survey of South Part North-Central Wisconsin.)

PORTEAGE COUNTY, WISCONSIN.

The material that has been mapped as muck in this area is organic matter, in varying stages of decomposition, which has accumulated in the lower lying areas. For the most part this soil is a black muck, composed of finely divided and well decomposed vegetable matter, varying in depth from 1 to 6 feet or more. Sometimes the decomposition has not progressed far enough to produce a true muck, thus giving rise to a soil more like peat. Such soil, however, seems to be the exception. The subsoil is usually a dark-gray sand of medium texture, but may also be a dark-gray sandy clay.

Some muck areas are found in the eastern part of the county within the limits of the terminal moraine. These areas are insignificant when compared with the areas found in the western half of the county. In the southwestern part of the county are swampy or marshy areas which aggregate nearly 100 square miles. In the northwestern and northern parts of the county are extensive muck areas. In many places this type of soil lies along stream courses.

The muck areas have a uniformly level surface and consequently are poorly drained. Both soil and subsoil are usually saturated with water or have water standing on the surface. Only a few instances have been noted in this county this season where it has been possible to walk over the muck areas without encountering water. Owing to their wet condition these areas are locally spoken of as "swamps" or "marshes." Artificial drainage is necessary before this type of soil can be utilized for general farming purposes. Drainage work is now being carried on in the southwestern part of the county.

The greater part of the muck is covered with a thick growth of coarse grasses, and in some areas a coarse moss is found. Many areas are treeless, supporting no vegetation other than grass, whereas other areas are covered with a thick growth of poplar, willow, or tamarack. The latter variety is especially characteristic of the muck areas in the northern part of the county, which are locally known as "tamarack swamps."

This soil, when thoroughly drained and brought under cultivation, should produce good crops of corn and potatoes. It is especially adapted to the growing of celery, onions, and cabbage. In other localities muck soil has been known to produce 500 to 800 bushels of onions per acre. In both Michigan and Indiana peppermint can be successfully grown on muck land. However, on muck land, even after being drained and cultivated, the danger from frosts is considerably greater than on the upland soils. For this reason the muck land is better

adapted for growing grasses, as they require a great deal of water and are not affected by frost. Among the grasses which have been found to thrive on such soil are timothy, redtop, brome grass and alsike clover.

At present about the only use made of the muck land is to cut the wild hay on it. In the spring of the year the swamps are usually very wet, but during a part of July and August they are dry enough to permit cutting the hay, although it can not be hauled away until late in the fall or early in winter, after the soil is frozen. The average yield is 1 to $1\frac{1}{2}$ tons to the acre. At present this type of soil is worth \$3 to \$8 an acre.

In order to study the fertilizer requirements of this soil a sample was collected from the Portage County drainage district and tests were made by the wire-basket method. The results obtained indicate that this soil responds favorably to all the fertilizers that were tried. Treatment with manure or acid phosphate alone or in combination with sulphate of potash resulted in a marked improvement in productiveness. Sulphate of potash alone or in combination with nitrate of soda or with lime gave a fair increase, while an increase equally good was secured by mixing equal parts of the marsh soil and poor Cecil clay. Lime alone or nitrate of soda alone gave a small increase.

In these tests wheat plants were used as an indicator, and the results are not held to be applicable to other and unrelated crops.

Reclamation of Swamp Lands.—In the southeastern part of the county is a large marshy muck area, locally known as "Buena Vista marsh". Within it are some smaller higher-lying areas of Miami sand.

Arrangements are being carried out for draining the main part of this marsh. A district known as the Portage County drainage district, including about 55,000 acres, has been established within the area. The present plan is to drain the area by digging six main ditches and three laterals, which are to carry the water westward into Ten Mile and Buena Vista Creeks. Each of these creeks flows from the swampy area westward into the Wisconsin River. Five of the main ditches are planned to run almost parallel with each other east and west, and are to be $1\frac{1}{2}$ to 2 miles apart. The two main ditches to the south, with two laterals, are to empty into Ten Mile Creek, while the four main ditches to the north, with one lateral, are to empty into Buena Vista Creek. The average fall is about 3 feet to the mile. Each ditch is to be about 30 feet wide and about $6\frac{1}{2}$ feet deep, with a slope of the sides of 1 to 1.

The land owners within the district are taxed to meet the expense of drainage. In order to determine the taxable valuation of each piece of land, a very careful survey of the area was necessary. In this survey three classes of land were established within the district, called "low marsh," "high marsh," and "hard land". The amount of water is greater over the "low marsh" than over the "high marsh" lands. Otherwise there seems to be little difference in the character of the soil and subsoil. "Hard land" includes areas of other types lying within or around the edge of the muck area where it comes in contact with other soil types, principally the Miami sand. The "low marsh" has been taken as a basis for taxation. It was assumed that "high marsh" would be benefited less by drainage than "low marsh" and "hard land" less than "high marsh". Accordingly 100 acres of "high marsh" was counted equivalent to 75 acres of "low marsh" and 100 acres of "hard land" equal to 25 acres of "low marsh". In this manner it was possible to determine readily the amount of taxes due from each land owner. The work of draining will probably be completed in about two years, then the lands will be improved as rapidly as possible.

West of the town of Plover, close to the Wisconsin River, is a comparatively small muck area known as the "Crooked Rift marsh". A drainage ditch is being dug in this area.

In the extreme northwestern corner of Portage County, bordering Eau Pleine River on the south, is still another mucky area, a part of what is locally spoken of as the "Dancy district". Plans have been made to drain this area, but up to the present time no work has been done.

(From Soil Survey of Portage County, Wisconsin.)

WOOD COUNTY, WISCONSIN.

The soil classed as Peat in Wood County consists of vegetable material in various stages of decomposition. In color it varies from brown to black. Only those areas are mapped as typical peat in which organic matter has accumulated to a depth of 2 feet or more. In some areas the depth is more than 15 feet. The organic matter, dependent on the stage of decomposition, varies from raw fibrous plant remains to very fine grained material that shows little trace of the original plant fiber. In most places the organic soil is underlain with fine or medium sand. In those parts of the county where the surrounding upland soils are heavy the underlying material is silt and clay, with some sand. In the southwestern part of the county the peaty matter is underlain with de-

composed sandstone which contains some shaly layers. These give rise to clayey material.

Throughout the marshy areas in the southern part of the county are numerous small sand "islands", varying in sizes from a few square rods to 2 or 3 acres. Where these "islands" occupy less than 25 per cent of the surface the land is mapped as peat. Many of the marshy areas have been burned over, leaving a deposit of ashes. Where the ash is of recent origin it appears as a yellowish or reddish-yellow layer, 1 inch to 3 inches thick, on the surface. In time this becomes incorporated with the underlying vegetable matter, and the soil takes on the appearance of well-decomposed peat.

The peat type of soil is mapped most extensively in the southern and southwestern parts of the county, where it is the predominating soil over many square miles. Through the center and northern parts of the county it occurs in numerous isolated areas of varying size, the largest being in the northeastern part of the county, in Milladore Township.

The surface of this land is nearly level. The small sand islands that occur in the areas in the southern part of the county are only slightly elevated above the surface of the marsh. Because of the flat topography, the natural drainage is very poor. Much of the peat land is included in drainage districts and is drained more or less thoroughly by large, open ditches.

The native vegetation on the open areas of peat land is largely marsh grass, sedges, and sphagnum moss. The timber growths are tamarack, spruce and cedar. Wild cranberry is abundant in some places. In the southern part of the county much of the marsh land is treeless. An extensive spruce swamp occurs south of Elm Lake, in Cranmoor Township, and another in the northwest part of Remington Township, near the county line. The marsh in the northern part of Milladore Township is largely open. Just east of the "island" in this marsh is an extensive area of tamarack and spruce. In some places along the borders of this marsh there is a heavy growth of black ash.

Much of this land is utilized for crops which do not require thorough drainage. About 1,000 acres are devoted to cranberries, largely in Cranmoor Township. There are several cranberry bogs in the western part of Remington Township. In addition to the land actually in cranberries, many acres of the marsh are used as a reservoir for water needed in cranberry production. Marsh grass is cut on a considerable acreage for hay. Where wire grass predominates the crop is sold to grass matting companies for \$15 to \$18 a ton.

Sphagnum moss is gathered and shipped to cities in considerable quantities for the use of florists.

Large areas of the peat land are being organized into drainage districts, and ditches are being installed. The land adjacent to the ditches is well drained, but at some distance from them the drainage is seldom adequate. After thorough draining the soil under proper farming methods gives good yields of certain crops. It is adapted to grasses, buckwheat, corn, potatoes, and various other crops. This land, being generally low, is subject to early frosts, which may prevent the ripening of certain crops, especially corn.

The peat land is deficient in the mineral plant-food elements. Before profitable crops can be grown over a long period of years these elements must be supplied. They can be incorporated to best advantage in the form of commercial fertilizer. Burned-over marsh lands give fair yields for a few years without the use of fertilizers, but in all cases this type of soil will ultimately require such treatment. With good management peat land can be profitably farmed.

The value of this land varies widely. Where no improvements have been made by way of drainage or clearing, the selling value is \$5 to \$15 an acre. Where drainage districts have been organized and outlet ditches constructed the land is usually held at about \$35 an acre. The purchaser of this land assumes the drainage tax. In addition to the open ditches forming a part of the drainage district, additional open-ditch laterals or tile drains may be needed.

Peat, Shallow Phase—Peat areas, in which the depth of the accumulation is less than 24 inches, are mapped as shallow-phase. The peaty material in these areas rests on a gray to white sand. Scattered throughout the areas are sand "islands" too small to show on the map. Areas in which these constitute more than 25 per cent of the surface material are mapped under the miscellaneous type of sands and peat (undifferentiated). Where the covering of peaty matter is shallow the soil resembles the Whitman fine sand or sand. Where organic matter has accumulated to a depth of approximately 6 inches or more the soil is mapped as peat, shallow phase; where it is of less depth the soil is classed in the Whitman series.

Shallow-phase peat occurs in irregular areas, along the borders of large marshes and in narrow depressions in the Plainfield soils. The largest area mapped is in the eastern part of Cranmoor Township. With increasing distance from the Wisconsin River the water table in this area lies closer to the surface. The soil gradually passes from Plainfield sand

through Whitman sand and peat, shallow phase, into typical peat.

The surface of the areas of shallow-phase peat is level and the natural drainage is very poor. The native vegetation is marsh grass, derges, sphagnum moss, willow and alder.

Outside the cranberry district most of the areas of this phase are in drainage districts and are more or less thoroughly drained. Adjacent to the ditches some fairly good yields are obtained. Good crops of rye and buckwheat were observed on this land in the course of the soil survey. Considerable marsh hay is cut on some areas. The shallow-phase peat has a value probably slightly higher than the typical peat, but requires practically the same methods of soil treatment.

Sands and Peat (Undifferentiated).—The soil material mapped as "sands and peat (undifferentiated)" is subject to wide variation. In general, it includes several areas of marsh land through which there are scattered innumerable low, flat "islands" of sand. The soil of the islands is a brown or yellowish sand or fine sand underlain by yellow, rusty-brown or nearly white sand of medium to fine texture. The content of organic matter in the surface soil is small and the material is usually loose and open in structure.

The sand islands included in this type are less than 10 acres in size. Those covering 10 acres or more are mapped separately, the soil being classed with the Plainfield series. The soil on these islands includes the same material as that in the larger areas of Plainfield soils. The marsh land included in this group may consist of any one or more of several types. Where the islands are very close together the surface material of the intervening lowland is usually made up largely of sand, fine sand or fine sandy loam, containing sufficient organic matter to have a black color. The subsoil usually consists of a gray or nearly white sand varying in texture from coarse to very fine. In most places it is fine in texture. Wherever these black, sandy soils occur in an area 10 acres or more in extent they are mapped separately and classed with the Whitman series.

A noticeable variation occurs in the subsoil of this mixed type. In a number of instances the underlying layer is a fine-textured, nearly white material, which is sometimes locally referred to as clav. It appears to consist chiefly of very fine sand, with a small proportion of silt and probably only a very small proportion of clay. This material is sometimes reached with the 3-foot soil auger, but it usually occurs at a greater depth and is most often seen along the banks of freshly-dug drainage canals, where it has been reached at a depth of about

3 to 8 feet. This bed of fine material does not appear to be continuous.

In some places the sandy peat is underlain with sandstone rock, associated with shaly material. Where open ditches are cut through such land thin beds of clay or sandy clay are sometimes seen. These have come from the weathering of the shaly sandstone rock. Areas in which this material comes within 3 feet of the surface are of small extent.

Small areas of peat are also included in this type of undifferentiated soils. This peat consists of vegetable matter in varying stages of decomposition, with which small quantities of fine earth have become incorporated. The depth of the peaty matter is variable. It is usually underlain by sand. Where the areas of peat are over 10 acres in extent they are mapped separately.

The size of the sand islands and of the intervening strips of marsh and the relative proportions of a given area occupied by each are variable. On the whole, it is estimated that the marsh and the sand islands have about an equal aggregate extent. In areas where the sand islands cover less than 25 per cent of the surface the soil on the islands is not differentiated and the area is mapped with the marsh soil. Where the islands make up more than 75 per cent of the total area the whole tract is mapped as one of the Plainfield types.

The type of sands and peat (undifferentiated) is mapped chiefly in the south-central part of the county, both east and west of the Yellow River. Near this river the type is made up largely of the Plainfield fine sand, Whitman fine sand, and shallow-phase peat. In the eastern part of the area of this type the Plainfield sand, Whitman sand, and shallow-phase peat are the chief soils included.

The surface of this land is level except for slight undulations due to the low sand islands, which rise only a few feet above the level of the marsh. The sand islands are usually fairly well drained, whereas the intervening areas of marsh are naturally poorly drained. A large proportion of this class of land has been incorporated in drainage districts and is now being reclaimed by large open ditches or canals.

The native vegetation on the sand islands is chiefly scrub oak, jack pine, poplar, and sweet fern, while that on the marshes is alder, willow, poplar, and marsh grass. Many of the marshy tracts have no tree or brush growth.

Only a very small proportion of this land is farmed. Small areas are included in some of the cranberry growing districts. A few small fields in areas where drainage has been partly established are under cultivation, but the results

have usually been unsatisfactory, owing in part to insufficient drainage. Marsh hay is cut from some of the open marshes, and wire grass for use in the manufacture of rugs and matting is cut in small quantities.

The construction of large, open ditches does not necessarily in itself provide adequate drainage for a soil of this character. The land bordering properly constructed ditches should be sufficiently drained, but at distances of about one-half mile or more, or sometimes even less, from the outlet ditch the drainage may not be sufficient. Thus the use of tile drains or additional open ditches is necessary. When adequate drainage has been provided this land will require careful management over a period of years before profitable crops can be grown. The supply of phosphorus and potash is low in all the soils making up the type, and these elements must be supplied. The supply of nitrogen in the marsh soils is high, but in the soil of the sand islands the nitrogen content is low and should be increased. The plowing under of legumes and the applying of stable manure or mineral fertilizers containing phosphorus and potash will assist in building up the productiveness of the soil on the islands. On the peat soils the use of fertilizer containing potash and phosphorus will be necessary before cultivated crops can be grown with reasonable certainty of profit.

(From Soil Survey of Wood County, Wisconsin.)

CORTLAND COUNTY, NEW YORK.

The muck in Cortland County is dark-brown to black, finely divided organic matter in an advanced state of decomposition, mixed with some mineral matter, and has poor drainage. It ranges in depth from 10 inches to 3 feet or more. In the smaller areas the muck rests upon bluish, claylike material; in most of the larger areas it is underlain by white marl, consisting of small shells mixed with calcium salts from such plants as chara, and in places has a thickness of 15 to 20 feet. In the areas underlain by marl the type closely resembles the Warners series as mapped in this State. Such areas are situated near Preble, Homer, Labrador Pond, and Cheningo. Smaller areas are encountered throughout the uplands in other parts of the county.

The topography is level or nearly level. In most places the land is swamp throughout the year.

The forest growth consists of hemlock, elm, ash, cedar and swamp maple, with an undergrowth of rushes, ferns and

other aquatic plants. None of this type of land is under cultivation at the present time. The price ranges from \$10 to \$39 an acre.

(From Soil Survey of Cortland County, N. Y.)

COLUMBUS COUNTY, NORTH CAROLINA.

The material classed as muck is vegetable matter which is fairly well decomposed and contains a high percentage of fine and very fine sand. It is uniformly black in color and ranges in depth from about 30 inches to 4 feet or more. The underlying material is a gray, sticky fine sand, locally known as "quicksand", or a light, sticky fine sandy clay of a gray or yellowish mottled color. In places a black, sticky fine sand occurs. Along the margins between the muck and the other soils the surface material contains more sand and is much shallower than the typical areas.

Muck occurs in the southeastern part of the county on the eastern edge of Green Swamp. One large body and a few small spots have been mapped.

The topography is prevailingly flat and level. Muck occupies the highest position of any of the mucky or peaty soils. Natural drainage has never been established throughout this material, but the canals which have recently been constructed will furnish ample outlets for lateral ditches, which will provide good drainage. The small hummocks or tufts distributed over the surface indicate that the muck has been burned over in comparatively recent times. When this muck is thoroughly drained and becomes dry it will burn out to the water table or to where the mineral matter predominates. It will be difficult to control the moisture supply.

The characteristic vegetation consists of bay pine, that is, small, gnarly pine trees having scraggy tops. There is a dense undergrowth of bay bushes and gallberry, with some ivy and huckleberry, all of which are interspersed with bamboo briars.

Throughout eastern North Carolina this material is generally recognized as "bay land" and it has a low agricultural value. It is in all probability the least productive of the soils lying within the drainage district.

It would be difficult to state the value of muck land in Columbus County, but in some of the adjoining counties land of this character can be purchased at a few dollars an acre.

Muck, Shallow Phase.—Shallow-phase muck consists of a brown muck or black, mucky fine sand, 10 to 20 inches deep, underlain by a gray or dark-gray, sticky fine sand. In places the muck or mucky fine sand extends to a depth of 30 to 36

inches. In some places the subsoil at any depth between 20 inches and 3 feet is very incoherent and is called "quicksand". Thin layers of gray fine sandy clay are encountered occasionally at depths of 20 inches to 5 feet.

This soil is typically developed on the west side of the Waccamaw Lumber Co. railroad, between Lake Waccamaw and Juniper Creek, and also 8 miles southeast of Bolton, in the eastern part of the Green Swamp. An area of considerable size occurs north of the Atlantic Coast Line Railroad $2\frac{1}{2}$ miles east of Bolton. The topography is flat, or nearly so, and natural drainage is poorly established. Some of the areas occupy depressions locally called "bays" and remain saturated throughout the year, except in excessively dry seasons. In these bays the water is perfectly stagnant, but in other places it flows sluggishly around on the surface and eventually reaches a drainage channel. Some of this soil lies within the Bolton drainage district or the Columbus drainage district No. 2 and is reached by canals.

None of this phase is under cultivation. It supports a scrubby growth of bay pines, together with a dense undergrowth of bamboo briars, bay bushes, gallberry, hardwood, shrubs, ferns, and mosses.

Outside the drainage district this land can be bought for \$3 to \$10 an acre.

Peaty Muck.—The peaty muck consists of more or less thoroughly decomposed vegetable matter, mixed with a small proportion of mineral matter and varying in depth from about 3 to 8 feet or more. The color is usually brown, although in places it is black. Except for the first few inches, the material is soft, smooth, and nonfibrous. Frequently at depths of 2 to 3 feet a brown or black muck is encountered. Underneath the peaty muck, at depths varying from 3 to 8 feet, is a drab, bluish, brown or mottled yellow and gray, heavy, plastic clay, or occasionally a fine sandy clay. Along the border of the peaty muck the surface material becomes shallower, contains a greater admixture of mineral matter, and approaches a true muck or black loam in color and structure. The peaty muck, when exposed to the action of the atmosphere, turns black on the surface and becomes hard, as was observed on the banks along the canals.

Peaty muck covers an area of 55.7 square miles in Columbus County. It is most extensively developed to the south and west of Bolton and to the southwest of Lake Waccamaw, along White Marsh and to the west of Crusoe Island.

The topography is uniformly flat. In places no definite stream channels have been established and the water

meanders over the surface. All the peaty muck areas are saturated or are covered with water during the entire year. The areas lying within the drainage district south of Bolton will be drained by the canals. The material contains about 75 to 88 per cent of vegetable matter. Experiments have shown that similar material shrinks and settles to an astonishing degree where cultivated for a few years.

All the peaty muck now supports a magnificent growth of merchantable timber, principally of cypress and gum, although maple and ash are conspicuous here and there. A rather thick undergrowth of bay bushes, myrtle, bamboo briars, and other aquatic plants covers the surface. The cost of clearing such land and restoring it to a condition suitable for cultivation is exceedingly high.

None of this land has been reclaimed or cultivated. Comparing it, however, with other areas in the south, it is reasonable to assume that fair yields of cabbage, celery, onions, and Irish potatoes may be obtained. Corn will probably give a satisfactory yield for one or two years.

Peaty Muck, Shallow Phase.—The shallow-phase peaty muck, to a depth of 18 to 24 inches, consists of a black, mucky material, carrying approximately 65 to 85 per cent of decayed vegetable matter. At an average depth of about 20 inches this material grades into a black, compact loam and the loam in turn grades into a gray or drab, sticky fine sand which extends to a depth of 3 to 5 feet.

Shallow-Phase Peaty Muck.—There are no extensive deposits, being confined to an area of 1.2 square miles lying $2\frac{1}{2}$ miles southeast of Bolton. The topography is nearly flat and natural drainage is not developed. The phase lies within Columbus Drainage District No. 2, and is traversed by one of the drainage canals, which affords an adequate outlet for lateral ditches.

The shallow-phase peaty muck supports a forest growth of cypress, juniper, black gum, maple and shortleaf pine, together with an undergrowth of vines and shrubs. The merchantable timber is being removed. None of this land is farmed. Since the establishment of the drainage district this land has been held at \$30 an acre, according to local information.

(From Soil Survey of Columbus Co., N. C.)

VALUE OF HUMUS IN FEEDS

By E. C. Dreyer.*

Humus is a rich organic substance, composed of disintegrated vegetation, which has taken place in water, which is an excellent medium for preserving, and only such substance which is of essential value as a food product and health preserver remains. The highly concentrated food ingredients are perfectly odorless and wholesome. A general average analysis shows that humus contains about 80 per cent of actual humus and about 20 per cent of ash. In the humus are the elements of food, also the humic compounds, while the ash contains very essential health preserving ingredients, our contention being that when humus (peat) is formed, by the vegetation composing it, it becomes another property, as much so as coal, or matters of a like nature.

After thorough investigation with various forms of peat we concluded it was necessary to have this peat specially prepared for use in stock feed, hence have concentrated our efforts in the sale of the product specially prepared by a chemical company. This is really a carbonized humus, used as a stock food ingredient.

By subjecting the raw peat to a very high degree of heat it practically becomes a charcoal. Charcoal is essentially pure carbon—that is, about 80 per cent of it, the balance hydrogen, oxygen and ash. Prepared humus is about 75 per cent carbon, balance nitrogen and ash. The nitrogen is protein; the ash contains calcium, sulphur, iron oxide, phosphate, magnesia—all valuable ingredients to feed. The ash contents are very valuable to the health of the animal, as they are the principal parts of a good “stock remedy.”

The peat used in preparing Wiedmer's Carbonized Humus is as clean and as wholesome a material as coal and charcoal in every respect.

The following is a letter written by Dr. H. E. Weidemann, chemist, together with his certificates of analyses:

“The peat, as found in the Wiedmer deposit, is in an excellent mechanical condition, and contains none of the long fibrous material so common in most peats. In the drying process, the air-dried material is carried through long dryers in such a manner that the peat comes into intimate contact with the flame. This not only dries the material thoroughly, but carbonizes it to a certain extent, which gives it the fea-

*Reprinted from *Flour and Feed*, January, 1918.

tures that are desirable in charcoal, i. e., great absorbing qualities.

"Charcoal is essentially pure carbon, with a small amount of mineral matter. The average analysis of charcoal is: 'Carbon 86 per cent, hydrogen 3 per cent, oxygen 9 per cent, ash 2 per cent.' The 12 per cent of hydrogen and oxygen has no bearing on its value, for they represent some of the undecomposed wood fiber.

"There is a marked difference between the composition of charcoal and peat, or humus, as they prepare it for the market. Their material contains nitrogen, phosphoric acid, oil, none of which is found in charcoal, and all of which are important ingredients in the feeding stuff.

"While I do not claim that carbonized peat has any particular value as a food with nutritive properties, it has been found that the material is completely assimilated during the digestive process of the animal, for no undecomposed peat has been found in the manure of animals that were fed a food ration containing peat.

"Carbonized peat has been found to have a marked influence when used in small proportions in mixed feeds, especially those containing molasses or cottonseed meal. Its action is, what we might term, of a corrective nature, and tends to overcome the evil effects that are often associated with the use of feeds of the above nature. This beneficial result was brought about, probably, by the mechanical nature of the peat, and perhaps, to a small extent, by its chemical nature.

"This material is certainly not objectionable to the animals, for they never leave any of it in the feeding bins when it is present in the feed, which would be the case if it were some absolutely inert substance that was disagreeable to the stock.

"The Wiedmer Chemical Co. have been selling this material for use in stock for years, and the results of research work carried on have been borne out in actual practice in different parts of the country.

"In conclusion, I will say that in my opinion this material is an advantageous ingredient in making certain classes of feed, and I see no reason why its use should be objected to on any grounds."

Humus.

Protein	17.84 per cent
Carbohydrates	35.50 per cent
Crude fiber	15.01 per cent
Fat	1.10 per cent
Moisture	10.06 per cent
Ash	20.49 per cent

Humus Ash.

Silica	51.66	per cent
Iron oxide	4.27	per cent
Alumina	9.15	per cent
Calcium Oxide	21.43	per cent
Magnesia	2.74	per cent
Sulphur trioxide	8.04	per cent
Phosphoric acid	1.57	per cent
Potash	0.60	per cent
Soda	0.51	per cent

As a comparison of our special prepared humus we quote the food analysis as furnished by the United States Agricultural department, of the principal feeds used by the farmer, adding thereto an average analysis of molasses and our humus. These are all figured out on a solid contents:

Article	Percent				
	Protein	Carbohydr's	Fat	Fiber	Ash
Corn	11.7	78.9	5.5	2.2	1.7
Oats	13.3	67.	5.6	10.7	3.4
Barley	13.9	78.4	2.	3.	2.7
Rye	12.	82.	2.	2.	2.
Wheat	13.4	80.	2.4	2.1	2.1
Flaxseed	24.6	22.2	14.3	8.1	7.9
Cottonseed meal	46.	25.7	14.3	6.1	7.9
Alfalfa	15.7	46.7	2.4	27.2	8.
Molasses	10.9	78.4	.....	.....	10.7
Humus	19.9	39.5	2.	16.3	22.3

The humus, like several of the other feeds named, is not intended as a complete feed in itself, but as a balance to a mixed feed. In preparing humus for food, or disease preventive, it is subjected to a very high degree of heat, which practically makes it a charcoal and the most efficient absorbent known, and when mixed with other feeds it will correct and counteract all harmful gases or acids. This is especially very essential in a sweetened feed, the base of which is molasses, which article sometimes causes souring, belching and bloating. When any reasonable percentage is used the humus will prevent this and enable the manufacturers to use as high as 50 per cent of molasses in his feeds with just as much safety as the 15 to 20 per cent usually used without humus. It will perform the same functions on gases or ensilage feeds, or any other wholesome food that the digestive organs of the animal cannot assimilate by itself on account of its not being a balanced food. The humus acts as a digester and makes it possible to force heavy feeding.

First Used in Europe.

Peat was first used as an ingredient in stock feed some 25 years ago in Europe. Present information tends to show that

the peat was intended as an absorbent to take up, or to counteract, the bad effects of molasses or sweetened animal feeds. We know little about the kind, or treatment of the peat used by European feeders.

An interesting quotation from the first article published, that we know of, in the United States, by Professor Charles A. Davis, United States Department of the Interior, Bureau of Mines Bulletin No. 16, under the heading of "The Uses of Peat" is, in part, as follows:

"In Europe, peat mull and peat litter prepared from moss and sedge peat have been used as the basis for the preparation of certain kinds of commercial stock foods. The chief ingredient in these preparations besides the peat—is molasses—actual analysis, however, by reputable agricultural chemists, show that this (meaning peat and molasses) material has a two-fold use; it is eagerly eaten by the cattle, and thus stimulates them to eat more than they otherwise would of fattening food, and the peat itself adds a small amount of proteid substance to the food; the peat also neutralizes certain bad effects of the molasses, so that larger quantities of it may be eaten. Although the weight of evidence gathered at agricultural experiment stations in the United States seems to show that condimental stock foods of the kinds usually sold are of the nature of stimulants, and do not give sufficient returns in actual gains in weight or condition of the animal to justify such use, the testimony as to the value of a mixture of molasses and peat mull as an addition to the rations of horses and other live stock, seems conclusive. Reports of its beneficial effects have been issued from time to time through a number of years from various European countries and from army veterinarians of Germany and England."

Some few years past two American manufacturers of sweetened feeds began using peat in a very small way, with varied results. On ascertaining their wants, the humus herein mentioned was prepared, as it was found they were trying to get the effects of charcoal, as well as to overcome the bad effects of molasses, etc., and the results are as two very large manufacturers and individual feeders say:

"We use humus in all of our sweetened feeds for fattening purposes; since doing this we find we can force feeding so as to get our stock on the market much earlier than we ever could before. We also find we can almost use double the amount of molasses in our sweetened feeds to what we ever could before using humus. It prevents any disorder to the animal's digestive organs; it eliminates belching, bloating and souring, and gives a smooth coat."

"We use humus in all our stock feeds. We have for several years past been feeding our stock on a sweetened feed made up principally of cottonseed product, in connection with molasses and humus. This sort of a feed could not be fed without the humus. We find we can obtain better efficiency out of our work stock and much better returns from our market stock, also practically eliminating losses by disease. We have for years been bringing young breeding stock from northern states and with all veterinary precautions had to practically abandon same on account of the losses through acclimating them. On our seeing what your humus did to our stock we have resumed the importing of young stock, especially calves, and since feeding them a feed containing humus we have almost totally overcome such losses. This is the most wonderful thing we have seen in our many years' experience in the stock business and we attribute it all to the use of your humus."

Used Successfully in Hog Feeding.

The Georgia Experiment station, under the direction of Professor P. V. Ewing, made some tests of feeding hogs cottonseed meal and digestor tankage, in connection with humus, with gratifying results, which results have not been published, but any one interested can get a statement from Professor Ewing.

A large manufacturing company of stock and poultry remedies operating several plants, on hearing that humus had such beneficial effects on the prevention of diseases to stock, after making a careful investigation of humus and its contents, began using it as a base of their manufactured product, utilizing the various ingredients of the humus, which are such, in part, of the ingredients of a successful stock remedy. We judge the success of the company's use of the humus from their increasing orders, as well as orders from other concerns manufacturing a like product, as they become familiar with humus.

In conclusion let us say that if the American agriculturalist will feed his stock a small amount of humus daily, he will, to a great extent, curtail the losses he annually sustains by death of his domestic farm animals. Most invariably those deaths are caused by intestinal disorders, generally brought on by improper feeding. Humus is no cure, but is a preventive of diseases, almost as much so as any remedy known.

PATENTS AND PROCESSES

Gas and By-Products from Peat.—T. Rigby and G. W. Andrew, U. S. Patent 1239969. Peat is gasified in a gas producer in contact with steam to facilitate the production of ammonia, the gases formed are cooled to 66 to 90°S. by contact with water in a washer; and the warm solution thus obtained is utilized as a source of steam which is mixed with air fed to the gas producer. The gases are then further cooled below 66°C. in a surface condenser to obtain methyl alcohol and other substances.

Carbonizing Peat.—H. Rosendahl, Norwegian Patent 28156, August 13, 1917. The peat is subjected to dry distillation, then carbonized in retorts, the heat and pressure being so regulated that the process is not attended with loss of volatile combustible matter; final carbonization is effected in closed retorts, with further distillation under increased pressure to produce uniform carbonization and uniform absorption of volatile substances by the porous product.

Nucleic Acid Derivatives from Peat.—W. B. Bottomley, (Proc. Roy Soc., vol. 90, 1917, p. 39). An aqueous extract of "bacterised" peat has a stimulating effect on the growth of *Lemna minor* in water culture and contains purine and pyrimidine bases and phosphoric acid, but no nucleic acid. Hence it was thought that nucleic acid might be present in raw peat. To determine this point, an alkaline extract of raw peat was precipitated with hydrochloric acid, as in the extraction of nucleic acid from soil; but the method proved laborious on account of the large amount of humic acid brought into solution. It was found better to saturate the peat with a 1 per cent sodium bicarbonate solution for 24 hours, which left the humic acid undissolved, and then express the liquid, concentrate it in a vacuum to a small volume, and pour it into absolute alcohol containing sodium acetate and hydrochloric acid. The precipitate was filtered off and dried in a vacuum, and both filtrate and precipitate were examined. The precipitate contained phosphoric acid and gave reactions for carbohydrates, but mild hydrolysis with a mineral acid failed to yield a purine base. The precipitate was heated, therefore, with 25 per cent sulphuric acid in an autoclave at 140°C. for 5 hours. From the hydrolysed product, silver-purine and silver-pyrimidine precipitates were obtained. The latter was found to contain uracil, and the former adenine. These results proved that the precipitate from the peat contained an adenine-uracil dinucleotide. The examination of the alcoholic filtrate showed the presence of a genuine-cytosine dinucleo-

tide. From these results it is concluded that the nucleic acid of the plants from which the peat was formed, had been decomposed by bacteria or other agencies, during the formation of the peat, into dinucleotides.

Gas from Peat.—C. O. Rasmussen, British Patent 101152 (1916). Gas is produced from peat, wood, etc., in the usual manner in closed retorts or retort kilns, and the gas as developed is again passed, together with steam or hydrocarbon vapors, through one or more retorts containing substances consisting chiefly of carbon maintained in a state of incandescence. For heating purposes the coke residue or charcoal obtained by driving off, wholly or in part, the volatile matter of the carbonizing coal, peat, wood, etc., may be used. In this way carbon monoxide is formed from a portion of the carbonic acid. In order to produce a greater quantity of usable gas and to promote the formation of carbon monoxide in the gas, water vapor is conveyed to the retort in which the reduction of the carbonic acid takes place, and in addition to carbon monoxide, greater quantities of hydrogen will also be formed by the process. The production of gas as described may take place in gas works which are ordinarily used for producing coal gas, as only small and unimportant or inconsiderable alterations of the gas works' plants are required. Likewise the production of coal gas and the producing of gas from peat or wood as described may take place at the same time in the same works, as some of the retorts in a retort bench, or some of the benches of retorts, may be used for producing coal gas, and others may be used to produce gas from heat.

Peat Distillation.—W. Thomas, British Patent 110217 (1916). Coal, lignite, peat, wood, or other material containing a large percentage of volatile constituents is distilled by passing these through numerous streams of gas, at a controlled temperature, which may be between 600 and 1000°F. The products of the distillation are stated to be smokeless fuel and a gas rich in benzol, toluol, and creosote oil or carbolic acid. A retort or chamber is fitted removably within a heating jacket and has a hinged door, a perforated grate, a gas inlet pipe and a gas outlet pipe. The heating jacket is mounted above or, preferably, on a producer of any well-known kind, generating heating gas which can be led along a pipe to a burner within a gas-heating chamber, or along a pipe into the heating jacket. A quick-action coupler connects the pipe to another pipe which conducts the hot gas from the retort to the surface cooler and condenser and a similar coupler connects the pipe to a coil which can be put in communication with the cooler and condenser by means of pipes,

and, by means of suitable pipe connections with the purifier or the gas-holder forming part of the plant, or with a natural gas supply pipe or a separate gas holder. The cooler and condenser having tube plates and baffles is the first of a series and may be washer scrubbers of well-known construction; the last of the coolers and condensers is connected to a purifier, which communicates with a gas holder. The passage of the hot gases from the retort through the coolers, condensers, and purifier to the gas holder is assisted by the action of a rotary exhauster, and the return flow of cool and purified gas from the gas holder to the retort, through the heating coil or through the first cooler, condenser, and the coil is assisted by means of a force pump. A form of apparatus suitable for use in small works is shown. The retort is preferably of tapering form, and has a hinged grate, a door, cover, and a jacket supplied with hot gases from a producer. A coil is fitted in the upper part of the producer. From the coil, the heated gas passes into the upper end of the retort through a pipe or into the lower end of the retort through a pipe; in the former arrangement, the gases of distillation pass to the condenser from the lower part of the retort and along a pipe or from the upper part of the retort and along a pipe. The hot gases from the jacket pass into a main within which is a gas main; the cool purified gas from the gas holder passes through the condenser into this main and is heated by the hot gas in the main, after which it is led by a pipe to the coil. A modified form of apparatus designed to obtain a more uniform working of the process is described. The producer is dome shaped and has a double wall through which the gas passes from a main to the retort, a number of pipes connecting the dome with various levels of the retort. Hot gases pass from the producer through apertures into a chamber in which the retort is set. An apparatus with regenerative chambers and arranged for use with movable or fixed retorts is shown. A producer is situated between regenerative chambers, each of which is divided into two communicating chambers by a vertical wall. The producer has a gas outlet pipe which can be put in communication with a stack pipe or, by means of pipes connecting with either regenerator through ports. After passing through one of the regenerators, the gases escape by a stack pipe, one being provided for each regenerator.

Peat Dewatering.--J. W. Hinchley and G. Gorton, British Patent 110380 (1916) Addition to British Patent 3998 (see this Journal, vol. 10, p. 112). In the process for expressing liquid from peat set forth in the parent specification, steam

at a pressure of 70 to 100 pounds per square inch is used as the gaseous fluid.

Preparing Peat.—J. W. Hinchley and G. Gorton, British Patent 110381 (1916) Addition to British Patent 101782 (see this Journal, vol. 10, p. 112). An improvement in the press described in the parent specification consists in the provision of separate openings or orifices for the admission of fluid to the material under treatment, and for the exit of the expressed liquid. A free non-return valve, or a mechanically actuated valve, may control the admission of fluid through the central fluid admission tube. Instead of the perforated admission nozzle, a distribution cap with vertical channels and radial grooves may be used.

Peat Dewatering.—J. W. Hinchley and G. Gorton, British Patent 110383 (1916). In expressing liquid, gummy, or colloidal substances from peat, after the manner described in previous specifications, hot water or liquid is admitted to the compression chamber instead of gaseous fluid, or two or more hot or cold gases and hot liquids are admitted successfully.

THE BRITISH WAR OFFICE PEAT FUEL CONTRACT.

In the second report of the Select Committee of the House of Commons on National Expenditure, an appendix gives the facts about the War Office contract for the manufacture of peat fuel. The British Armies in France require large quantities of fuel, including coke and charcoal for use in dugouts and trenches. In view of the difficulty in obtaining charcoal and its high cost, the possibility of using a form of briquet made from peat was considered. Wet carbonizing limited offered to manufacture peat briquettes, costing 35s. at the factory, and the samples, after being tested, were pronounced satisfactory for trench warfare and economical in transportation. In the course of negotiations proposals were considered for re-starting Wetcarbonizing's factory and also the establishment of another factory in France, but the latter plan fell through on account of the Ministry of Munitions withdrawing its previous undertaking to release the necessary steel for building purposes. Afterwards it was considered that the probable saving in fuel was not worth pursuing as a financial proposition, but that the saving in tonnage deserved consideration. The War Office advanced £13,000 (\$63,000) to Wetcarbonizing Limited, secured on the company's assets. A new contract is now under consideration, providing for the re-instatement of the factory at Dumfries, and for its utilization for the production of 60,000 tons of briquets a year.

(Through the Colliery Guardian.)

Mr. Chas. Knap, Secretary,
American Peat Society,
Whitehall Building,
New York City.

Dear Sir:—

I, the undersigned, being interested in the development of our peat resources and in the welfare of the peat Society, beg to make application to membership in your Society, for which I enclose \$5.00 as annual dues.

Signed

Address

Date

Journal of the American Peat Society

Vol. X

JULY, 1918

No. 3

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Doings of Our Members

W. F. Todd of St. Stephen, N. B., is working peat litter and peat moss products this season and promises us an article on the results of his work, which we eagerly look forward to.

L. J. Le Vague owns a peat bog located near Seney, Mich., on the D. S. S. & A. Ry. of about 1,200 acres and 10 to 25 feet deep. He would like to develop this deposit provided he can obtain capital to do so.

C. D. Jenkins of the New Era Development Co. advises us that they are erecting a plant at Norwood, Mass., consisting of 100 H.P. engine and 125 H.P. boiler, with machines for converting peat to fuel, and also intend to manufacture peat filler.

F. A. Wildes of Hibbing, Minn., some 14 years ago made a small briquetting machine for peat and experimented with different binders with considerable success. Lack of capital at that time required him to suspend operations. As the coal situation is acute in Minnesota and there is an abundance of peat there, he intends to start something if he can obtain some capital.

Prof. S. K. Soper, Dean of the School of Mines, Oregon, State Agricultural College, will devote this summer to field investigations for the U. S. Geological Survey. The report is to be used by the Geological Survey as a war measure and will be hurried to completion. Particular attention will be paid to the possibility of utilizing our peat resources for fuel and fertilizer, and the report will also contain notes on the occurrence and distribution of peat moss for surgical dressings in the army.

C. A. Kellet, superintendent of the Crex Carpet Company, sent us a sample of the so-called "wire grass" which grows on their peat lands in Minnesota and Wisconsin. This grass is what is known as *Carex Filiformis*, or as is frequently called today, *Carex Lasiocarpa*. The occurrence of this grass is frequently mentioned in reports on the peat bogs of Michigan, where it appears to be very common, especially in northwest lower Michigan. It is also very common in northern peat bogs, especially of Wisconsin and Minnesota.

J. H. Tatum, Second Vice President of Tatum Bros. Company, Miami, Fla., advises that they own some very valuable peat deposits in the Everglades; at one point there are some 5,000 acres where the peat tests 4.07% nitrogen and the subsoil nearly 4%.

Ernest V. Moore of Montreal, Canada, has been commissioned by the Canadian Government to erect two entirely new peat plants for investigation purposes on a bog in Ontario. He anticipates having these plants built in time to try out this year, but does not think he will be able to make much fuel. One of these plants will be very similar to the one he built at Alfred, redesigned in the light of the experience obtained there. The other is an entirely new design of his own, and if successful, will prove a distinct step forward in the manufacture of machine peat fuel. If the machine works out successfully, it will be a device that will excavate, lay out and dry, do the cubing and provide means for harvesting to a store pile, all in the one piece of apparatus, and he states it will be more simple and less costly per ton of output than any plant known to date. As soon as his work has matured Mr. Moore promises us further information.

George W. Hall of North Adams, Mass., who has been a peater for ten years, has watched the various attempts of making peat fuel with a strong belief that the time would come when peat would do its share in keeping New England homes warm during the winter months. Mr. Hall believes the time has now arrived. He states that last winter he made a peat fire in the open grate of one of the local banks where it received favorable attention. In our last issue (p. 50) we mentioned that he had purchased the Dolberg peat machine of our late president, Carl G. Kleinstueck. Mr. Hall intends to install this machine at his bog and get out a moderate amount of peat this summer. We received a sample of the peat Mr. Hall manufactures and it contained 12.53% moisture.

The dried peat tested:

60.79% Volatile matter,
39.21% Coke,
8.51% Ash.
2.72% Nitrogen,

which should make a good fuel peat.

Truck Growing on Peat or Muck Soils

Prof. H. C. Thompson.

The undrained, undeveloped peat or muck soils represent one of the greatest natural resources of the United States. The early settlers in various parts of this country passed by these, the richest lands, because they considered the "swamps" worthless and a menace to health. Even in this day of enlightenment thousands of otherwise intelligent people speak of muck or peat soils as worthless, or of little value from the standpoint of crop production. While a good type of peat or muck soil is the richest soil to be found, there are some that have little value, or else we do not know enough about them to intelligently handle them.

As peat soils are swamp soils, the first thing that must be done to put them in condition for production of crops is thoroughly to drain them. This drainage not only gets rid of the surplus moisture, but favors aeration, and the growth of beneficial bacteria and fungi. The plant food in peat is in an unavailable form before it is drained and aerated, or until the decay organisms have had a chance to break down the coarse material into soil. Before undertaking the development of a peat bog, a thorough study should be made of the possibility and practicability of drainage. Some bogs are so situated that it is not practicable to drain them. Peat soils can be drained by open ditches or tile. In most sections of the East open ditches are used, while in the Central West tile is used to a large extent. Because of the fact that the soil settles very rapidly for a few years after the land is drained, it is considered best to use ditches for the first two or three years.

As the subject of draining peat soils has been thoroughly discussed by experts at other meetings of this Society, the writer will not go into a detailed discussion of this subject, but merely point out a few important points. After the land has been under cultivation for a few years it is more desirable to use tile where possible than open drains. The open drains need frequent attention because the soil caves in, filling up the ditches. In fact, the ditches should be cleaned every

year, and this makes this system of drainage more expensive than tile drainage. Open drains divide the field into narrow sections, making it impracticable to use large implements and machinery, and a considerable space is lost. Weeds grow up along the ditches and unless they are frequently cut they fill the soil with seed.

Many owners of peat soils have made the mistake of using small tile. Most authorities agree that a 4-inch tile is the smallest that should be used in draining peat soils, and in long runs the tile should be larger. Mains should not be less than 6 inches in diameter, and for the lower portions of long mains, not less than 8-inch tile should be used.

After a new bog has been drained it is best to grow some general farm crop for the first year at least. Corn is often grown the first year and sometimes for several years in order to get the peat in condition for growing vegetable crops. Most vegetables grow better on a well decomposed peat or muck soil than on raw peat. In addition to this it is difficult to plant and cultivate small growing crops on coarse peat, or soil which contains roots and stems of trees and shrubs.

The vegetables most commonly grown on peat soils are onions, celery and lettuce, although cabbage, spinach, potatoes, beets, parsnips, and carrots are often grown successfully on these soils. Cauliflower and Chinese cabbage have been produced on peat, but these crops are not to be generally recommended at the present time. In California, asparagus, beans, and other vegetables are grown on what are known as tule lands, a type of peat or muck.

Preparation of Peat Soils.

Peat soils should be thoroughly prepared by plowing, harrowing, planking, etc. The soil should be thoroughly compacted by rolling or planking before sowing the seed or setting out the plants. This compacting reduces the danger of injury by winds, improves the moisture conditions by establishing better capillary action, and makes a smooth, even surface for seed sowing. The usual practice in preparing peat soils for crops is (1) plow it with a turn plow, preferably a light one with a long mold board, (2) disking, (3) harrowing with a smooth harrow, and (4) planking or rolling.

Fertilizer.

As different crops require different treatment, no specific directions can be given that will cover all crops and all conditions. Peat soils in general are high in nitrogen and very low in potash. On new soils, however, the nitrogen is

so slowly available that it is usually advisable to apply some readily available nitrogen fertilizer. Manure often gives excellent results, especially on new soils that are poorly supplied with bacteria and fungi which break down the unavailable food material into available plant food. Manure also furnishes plant food. As peat soils are deficient in potash, this element is the main one to be supplied in commercial fertilizers. In fact, many truck growers apply nothing but potash, using 200 to 400 pounds of muriate or sulphate of potash to the acre. Many truckers in the East apply a complete fertilizer analyzing 2 to 4 per cent nitrogen, 6 to 8 per cent phosphoric acid and 8 to 10 per cent potash, at the rate of 1,500 to 2,000 pounds to the acre. Under most conditions this is a waste, as experiments have shown that nitrogen is of little value, except a small quantity of readily available nitrogen, applied in the spring, or during the summer when the crop has been checked. A small amount of phosphoric acid can be used to advantage, but under any conditions 400 to 500 of 16 per cent acid phosphate or its equivalent to the acre is sufficient. A ton of fertilizer containing 8 per cent phosphoric acid has the equivalent of 1,000 pounds of 16 per cent acid phosphate. The writer is convinced that the muck soil truckers of the East can cut their fertilizer bill in two without reducing the yield. This can be done by reducing the amount of nitrogen and phosphorous applied on all truck crops, and possibly eliminating the nitrogen entirely for onions.

Where the soil is acid it is advisable to add lime, although when the land is thoroughly drained and put under cultivation the acidity usually disappears. Before applying lime it is best to test the soil for acidity, as lime should not be applied to neutral or alkaline peat soils. When lime is needed it may be supplied in the form of finely ground limestone, marl, slaked lime, or burned limestone. The burned lime is the most active and, for quick results, is probably preferable to the ground lime. Ordinarily one ton of burned lime to the acre is sufficient, but on very sour soils two tons should be applied at the first application. When ground lime is used apply 2 to 4 tons per acre for the first application, depending upon the acidity.

Onions.

Onions grown on peat soils are usually produced from seed, although sets are sometimes used for early bulbs. The seed is sown with hand seed drills at the rate of 4 to 6 pounds per acre. The rows are spaced about 14 inches apart and all cultivation is done by hand with wheel hoes of various kinds

and with scuffle hoes. Hand weeding is necessary to keep the onions clean. This is the most expensive operation in connection with onion growing, but is much more easily done on peat than any other type of soil.

When the onions reach maturity they are pulled by hand and allowed to remain on the ground long enough to dry. The tops are then clipped off, using hand shears, such as are used for sheep, or by means of machine toppers. After topping, the onions are usually put up in crates and piled in the field to dry, or hauled to the curing sheds for curing. After the onions are cured, or when wanted for market, they are screened to separate them into the different grades and remove dirt and the outside scales. The bulbs are usually graded into three grades—primes, seconds, and “picklers.” The primes include all those of $1\frac{1}{4}$ inches in diameter and larger, the seconds consist of those from $\frac{3}{4}$ to $1\frac{1}{4}$ inches in diameter, and the picklers include all onions below $\frac{3}{4}$ inch in diameter. (See Farmers' Bulletin 354, U. S. Dept. Agri.)

Celery.

This crop probably gives the greatest returns per acre, but also is the most expensive to produce. Celery requires more expert labor than any of the other crops commonly grown on peat soils and also requires heavier fertilizer. For the expert grower, celery is one of the best crops for peat soils, but for the inexperienced man other crops should be produced.

For growing an early crop of celery the seed should be sown in a greenhouse or in hotbeds during the winter. The young plants may be transplanted to stand about one inch apart each way in a hotbed, and left there until time for planting in the field, or the plants may be left in the seed bed until planting time. The transplanting develops a stocky plant with a mass of fibrous roots, but the extra labor required is not justified, except for very early celery. The seed for medium and late celery is usually sown in an open bed in the field near a water supply, so the beds can be frequently watered. On muck soils in the East the celery plants are set out when quite small, 2 to 3 inches in height. In California, however, the plants are allowed to develop to considerable size (4 to 6 inches) before setting to the field. The plants should be set in straight rows equal distance apart for convenience in cultivating and spraying. Celery to be blanched with boards or paper is usually planted in rows about 3 feet apart and 4 to 6 inches apart in the row. When

soil is to be used for blanching the rows should be at least four feet apart. Many growers have the rows of late celery 3 feet apart and blanch every other row with boards or paper. When these rows of celery are taken out the others are blanched with earth. When the crop matures during warm weather, boards or paper should be used for blanching, but when celery matures during cool weather, soil is considered best.

Celery should be given clean cultivation throughout the season. Most of the work of cultivating can be done with horse implements, but when the plants are small, hand cultivators should be used near the rows. Hand weeding is usually necessary to keep the weeds down between the plants in the rows. Where diseases are severe the celery should be kept well sprayed. This spraying should begin in the seed bed and continue until the celery is grown. Applications should be made often enough to keep the foliage well covered. Bordeaux mixture is the best spray mixture for diseases of celery and it is usually considered advisable to add soap to the mixture in order to make it adhere well. The 4-4-50 of the 4-6-50 Bordeaux mixture is usually used. These are made by using 4 pounds of bluestone (copper sulphate), 4 to 6 pounds stone lime to 50 gallons of water. It should be borne in mind that any spray material is used as a prevention rather than a cure for disease. The spray should be applied with high pressure sprayers in order to get a fine mist. (Write to your State Experiment Station for information on spraying.)

The blanching of celery requires from 1 to 3 weeks, depending upon the weather. In hot weather, or when celery is growing rapidly, a week or ten days is long enough, but during cold weather ten days to two or three weeks is often required.

In harvesting celery it is cut below the surface of the ground, leaving a part of the root system on the stalk. The cutting is done by means of a hand implement or with horse-drawn cutters. The bean harvester is quite often used in New York State. Some growers have a cutting bar attached to the side of an ordinary turn plow. After the celery is cut or dug, the outside leaves are stripped off and the celery is packed in crates for shipment or hauled to the wash house, where it is washed and bunched. A considerable portion of the early celery is washed and bunched on the farm, but most of the late celery is packed in the crates without washing and bunching. Celery should be graded into at least two grades

according to size, whether sold in the rough or washed and bunched.

Various types of crates are used, but the most common one is a slat crate about 22 by 23 by 23, or 23 by 24 by 24. This crate is rather large and unwieldy to handle. A crate 14 by 24 by 24 is much more easily handled, is not as easily broken, and when used for storing celery gives much better results than the large crate.

Lettuce.

Lettuce is an excellent crop to grow on peat soils because it develops in a short time and fits in well with other crops. A crop of lettuce can be grown on land that is to be planted to late celery the same season, and a crop can be produced after a crop of onions or early celery. Two or three crops can be grown on the same land during the season, but it is better to change the crops rather than grow two or more crops of the same thing in succession.

Lettuce seed for a very early crop is usually sown in a hotbed and the plants are transplanted to the field as soon as the danger of freezing is past. For the general crop a common practice is to sow the seed direct to the field and when the plants begin to crowd, the lettuce is thinned to stand about 8 inches apart in the row. The rows are spaced 13 to 15 inches apart and all cultivation is done by hand. In order to produce crisp, tender lettuce the plants should be kept growing all the time. Whenever there has been any check to growth it is a good plan to apply 100 to 150 pounds of nitrate of soda per acre to stimulate growth.

Big Boston is the variety commonly grown on peat soils. A large solid head is in demand on the market and the variety mentioned more nearly meets the requirements than any other.

As soon as the heads are ready for market they should be harvested immediately, as they deteriorate rapidly. It is often necessary to make two or three cuttings in order to get the heads in their prime. In harvesting, the plants are usually cut near the ground with a large knife. Any discolored, dirty or diseased leaves should be removed before packing the heads. The heads should be carefully graded. Large, solid heads which are free from injury should ordinarily be packed in a fancy package. A box holding 24 heads in two layers of 12 heads each is the best type of package. The second grade is usually packed in hampers. Some growers pack altogether in hampers, or baskets, and do not grade, but this is a poor practice. In many cases 24 heads well graded and packed in a

box, sell for more than 36 to 48 heads packed in hampers without grading.

While peat soils are better adapted to the production of certain vegetables than to most other crops, it is very evident that a very small percentage of such soils should be developed for vegetable production. If two per cent of all peat lands in the United States was planted to vegetables, there would be such an over-production that the returns would be less than the cost of production. For this reason, any large development must be for the purpose of growing crops other than vegetables. As the demand for perishable products increases, no special effort will be necessary to induce farmers to produce these crops. The utilization of any considerable area of peat soils for agricultural purposes must be along the line of general agriculture rather than vegetable growing.



FIG. 1.

A peat swamp being cleared of bushes and "bogs" by means of a "bogging machine" pulled by a gasoline tractor.



FIG. 2.

A crop of onions growing on newly cleared land. This land was cleared in October and the crop shown in this illustration was produced the following season. The clearing of this land is shown in Figure 1.



FIG. 3.
A field of celery grown on muck land. Note the method of blanching with soil.

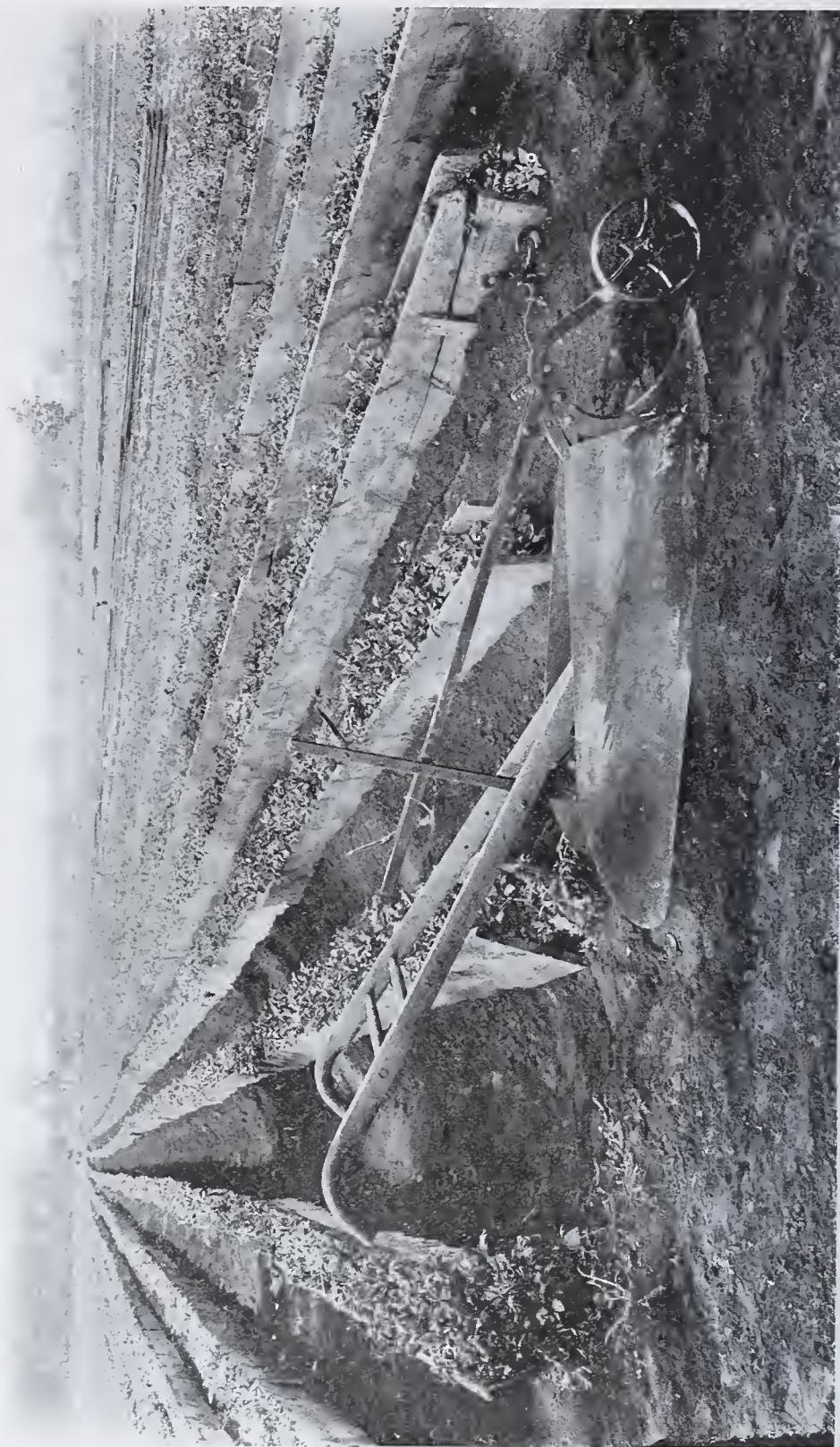


FIG. 4.
A field of celery grown on muck soil showing method of blanching by means of board.

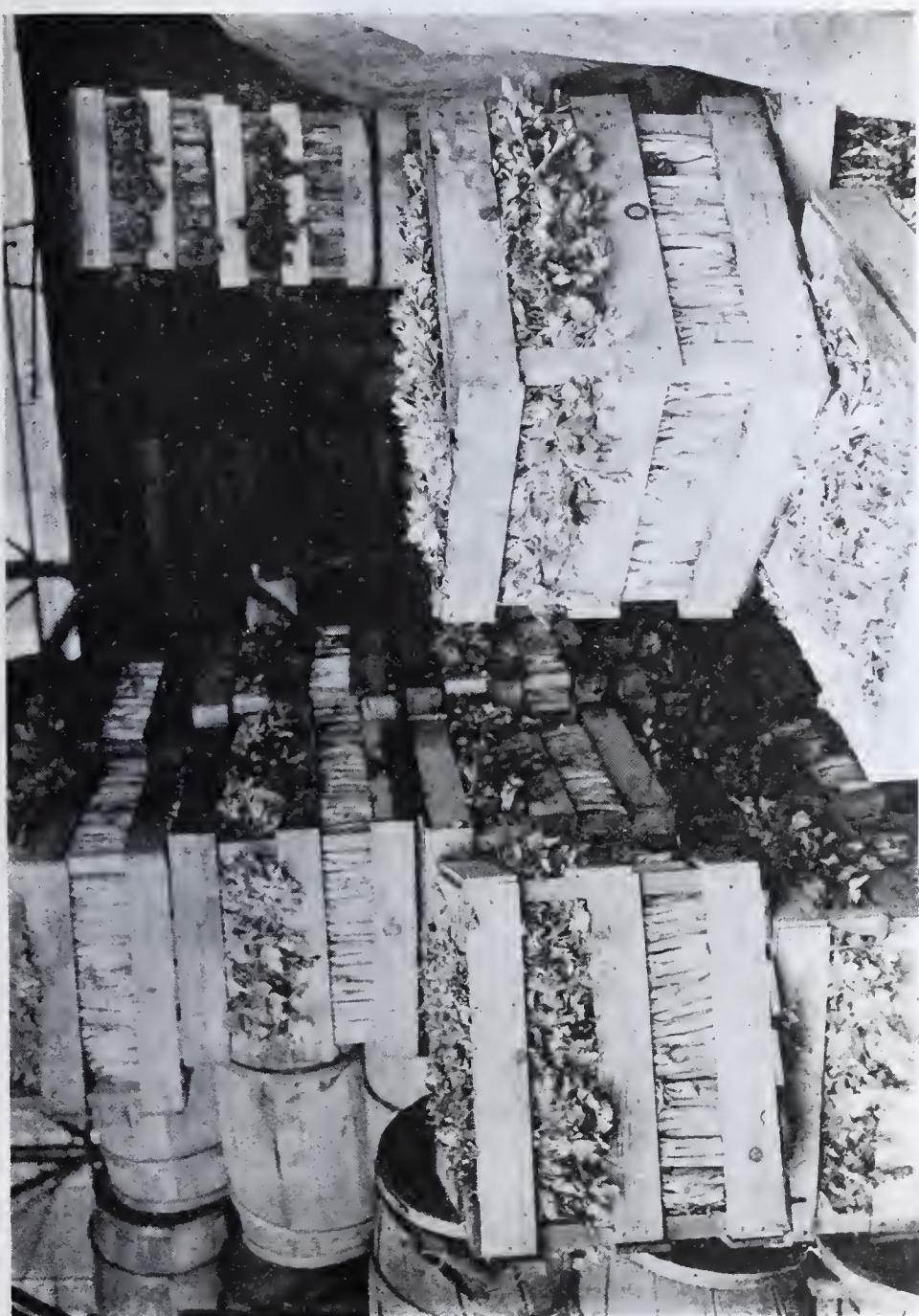


FIG. 5.
A type of celery crate used for shipping celery in the rough from California. This general type of crate is used in nearly all celery growing regions of the north.

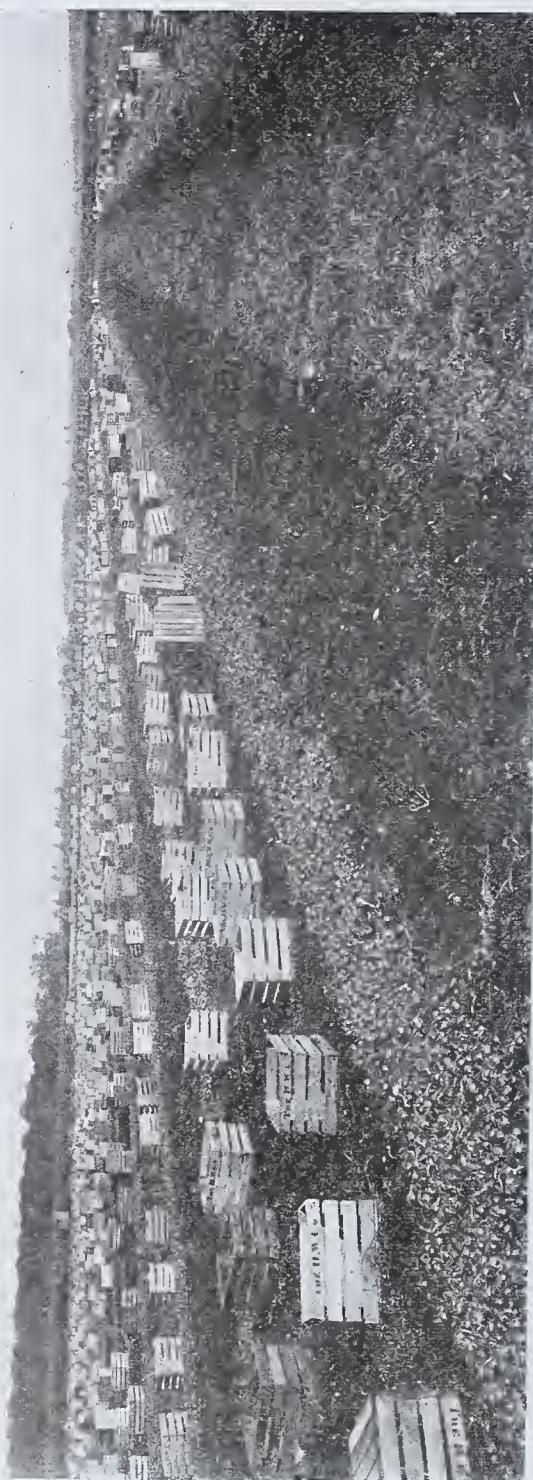


FIG. 6.

A field of onions grown on muck soils. These onions have been pulled and allowed to dry in the field and are now ready to be taken up.



FIG. 7.

Lettuce growing on muck soil.

PEAT FUEL FOR BRITISH ARMIES IN FRANCE.

An appendix to the second report of the Select Committee on National Expenditure contains information concerning the proposed use of peat briquets by the British Armies in France. Tests were made upon briquettes supplied by Wetcarbonising, Ltd., and the reports pronounced them to be satisfactory for trench warfare and economical in transportation. The Advisory Committee on Army Contracts considered the matter on various occasions in 1917. The Company proposed that the War Office should advance £50,000 for the adaptation and re-starting of their factory at Dumfries, the sum to be secured by a first charge on the whole property. The output was estimated at 170 tons a day, and the cost 35s. a ton at the factory. They also proposed a second scheme for the erection of a small factory in France, capable of an initial output of 100,000 tons a year and of expansion to 300,000 tons. The estimated initial cost of plant was £400,000, which was to be advanced by the Government, the factory to be Government property. The cost of the briquettes was to be 40s. a ton. As the probable saving in fuel was estimated at only £30,000 a year, the Advisory Committee was of opinion that as a financial proposition it was not worth pursuing, but as a means of saving tonnage it was to be recommended. The recommendations were not accepted in detail, but an amended scheme, substantially on the same lines, was approved by the various departments of the War Office, the Ministry of Munitions, and the Treasury, and a contract was finally made between the War Office and the Company in September, 1917. The Select Committee now reports that the scheme for erecting the factory in France has been abandoned. The factory at Dumfries has to some extent been dismantled, and £13,000 has been received from the War Office by the Company as an advance. The committee regrets that a position should have been created which involves possible payments from public funds owing to the adoption and abandonment of this scheme. A new contract is now under consideration providing for the re-instatement of the factory at Dumfries, and for the production of 60,000 tons of briquettes a year, but in view of the enhanced cost of materials and of labor, the expenditure involved would be considerably more than that contemplated under the first scheme for the production of about an equal quantity.

Fuel Resources of Canada with References to the Pulp and Paper Industry*

By B. F. HAANEL, B.Sc.,

Chief Engineer, Division of Fuels and Fuel Testing,
Mines Branch, Dept. of Mines, Ottawa.

The fuel resources of the Dominion of Canada are composed of the small areas of anthracite coal near the boundary of Alberta and British Columbia, the bituminous coals which occur in British Columbia, Western Alberta, Nova Scotia, and, to a small extent, in New Brunswick, and the great lignite fields of the Provinces of Alberta and Saskatchewan.

Midway between these admittedly large reserves of fuels is a vast area devoid of coal or lignite formations of any economic value, but through which are scattered large deposits of peat. This area, comprising principally the provinces of Ontario, Quebec, and practically the whole of Manitoba, is well populated and industrially organized.

The central provinces, and, to a large extent, the prairie provinces, are dependent on imported coal for domestic, industrial and railway purposes.

Crude oil is known to occur in economic quantities in only one province, viz., Ontario, but the maximum annual production from the oil fields of this province is exceedingly small—less than 7,000,000 imperial gallons—and, moreover, is rapidly decreasing. Vigorous and intelligent prospecting may, of course, disclose new oil fields of economic importance, but such discoveries will have to be made before our position regarding a domestic supply of crude oil is improved.

Canada, however, possesses other sources of oil, which, if vigorously exploited, would very appreciably decrease our growing dependence on other countries for this almost indispensable commodity. The principal sources of oil known to exist in Canada are the rich oil shales of New Brunswick and Nova Scotia. Oil shales also occur in other parts of Canada, but accurate information concerning their extent and economic value is required before they can be added to the immediate available sources of oil. Bituminous coals and lignites constitute another valuable source of oil.

The economic utilization of the coking and non-coking

*Reprinted from Pulp and Paper Magazine, 1918, Vol. 16, p. 225.

varieties of bituminous coal which occur in large quantities in the extreme east and west presents no difficulties. These coals in their natural state, i. e., without any preliminary treatment, are entirely suitable for industrial and metallurgical purposes, and they can be used for domestic purposes, but not with the same degree of satisfaction as the anthracite coals commonly employed for that purpose.

On the other hand, a large portion of the western lignites and the peat content of the numerous bogs of the central provinces are not, in their natural state, suitable as fuels for domestic or industrial purposes. These fuels must be submitted to treatment before they can be placed on the market for general distribution.

Canada's Fuel Requirements.

The total fuel requirements of this country during the year 1916 amounted to nearly 30,000,000 tons of coal; 299,426,121 imperial gallons of crude and refined oil products, and firewood valued approximately at \$60,000,000. Canada's production of fuels for the same period was 14,483,395 tons of bituminous coal—of which 2,135,359 tons were exported; 6,934,288 imperial gallons of crude oil, and wood fuel to the value of \$60,000,000. From these statistics, it will be seen that Canada is dependent on the United States for about 55 per cent of her coal requirements, and 98 per cent of her crude and refined oil products.

Transportation of Canadian Fuels.

As far as the existence of sufficient coal reserves is concerned, Canada is known to possess deposits which, at the present rate of consumption, will last many thousands of years. The problem, therefore, with which this country is concerned is not one created by the absence of coals, but by their peculiar geographical location.

The east and west are well provided with fuel for all purposes—even sources of fuel oil to a limited extent, if we take into consideration the oil shales and the possibility of utilizing our bituminous coals and lignites for the purpose of recovering various oils—but the central provinces are absolutely dependent on other sources for the various fuels to meet their everyday requirements.

The prairie provinces can be made entirely independent of imported coal for all purposes, by erecting plants for carbonizing and briquetting the low grade lignites which abound in this section of Canada. Manitoba and perhaps a portion of western Ontario could also be supplied with this kind of fuel.

Carbonized lignite briquettes are practically equal to anthracite in heating value, and are entirely suitable for every purpose for which that coal is now used.

The fuel situation of the greater portion of the provinces of Ontario and Quebec is far more serious than that of the other provinces. The coal deposits of the east and west and the lignite deposits of Alberta and Saskatchewan are too far removed from Ontario and portions of Quebec, to enable the transportation of mined coal to be made profitably; consequently these provinces will be forced to buy fuel for industrial and domestic purposes in the cheapest market.

Up to the present time, as mentioned before, Canada has been dependent on the United States for 55 per cent of her coal and 98 per cent of her crude and refined oil products. Present indications are that the United States Government will prohibit the export of coal—especially anthracite—in the near future, since the exhaustion of the sources of this latter coal is now only a matter of a comparatively few years. Even though this state of affairs does not arise for some years, the increasing price of the imported coals will render their use uneconomic in many industries. Unless much lower freight rates can be obtained for the haulage of domestic coal over long distances, the industries of the provinces affected by the high cost of coal will, in the near future, have to move to sites where cheap power is available. Industries dependent on cheap power should, in general, be located in the vicinity of large hydro-electric power plants, or be provided with electric energy generated from coal in large central plants. Power plants using solid or liquid fuels should be situated conveniently with respect to cheap transportation facilities, preferably water transportation.

The Province of Ontario, which will be the most seriously affected in the event of the cessation of coal exports from the United States, fortunately possesses immense deposits of peat entirely suitable for the manufacture of peat fuel. Numerous plants located logically with respect to the economic distribution of the manufactured peat fuel would greatly assist in relieving the present situation regarding fuel for domestic purposes and, in certain instances, fuel for industrial purposes.

PEAT FUEL.

Description of Peat.

Peat is a substance formed by the incomplete decomposition of vegetable matter either in or in the presence of

water. The deposition of peat-forming matters may not be continuous, but occur at irregular intervals; moreover, the vegetable matter composing the detritus laid down in the different periods may be of many and different species. Consequently, a bog of considerable depth will have represented a series of strata or layers which may comprise many different forms of plant life. The decomposition to which the various layers are allowed to proceed also may be quite different. Material composing a peat bog may consequently be far from homogeneous.

The layers composing an old and well humified peat bog are often so altered that scarcely a trace of the original plant life remains. In such cases, the peat mass is composed of such minute particles that in its natural state (associated with water) it possesses many of the properties of a colloid. The chemical alteration of the plant life entering into the formation of all peat bogs gives rise to a complex hydrocarbon compound, called hydrocellulose. This is a true colloid, and has properties which are of the greatest importance in the process of manufacturing peat fuel.

This substance is distributed throughout the peat bog, but the quantity present in any particular section or layer is dependent on the plant life composing such portions or sections and the degree to which the humification, or chemical alteration, was allowed to proceed. This gelatinous matter is, therefore, seldom, if ever, found uniformly distributed throughout an entire bog.

Peat, in its natural state, is generally associated with about nine times its weight of water. It is, therefore, evident that 1,800 pounds of water must be removed in order to recover 200 lbs. of solid matter. Moreover, this solid matter not only represents the combustible substance, but also the ash and mineral matter which is associated with the peat.

The separation of this large quantity of water, and the handling of so large a quantity of raw peat substance, in order to obtain a comparatively small quantity of combustible matter, represent the real problems with which we are confronted when an attempt is made to manufacture peat into a fuel, on a commercial basis, and in thoroughly economic manner.

Ignorance of the physical and chemical properties of peat, and a complete lack of knowledge concerning the results of the efforts made by European investigators, distributed over more than a century, are directly responsible

for the lamentable failures with which the attempts in this country have met.

The Manufacture of Peat Fuel.

To simply and rapidly accomplish the removal of the water content of peat, and to convert the substance into a convenient form of fuel, has led many people to employ presses of various designs, and to briquet the residue. All such attempts were doomed to failure, since the very nature of peat prohibits the employment of pressure for the removal of the water. The water content of well humified peat cannot be reduced to below 80 to 85 per cent by pressure alone, and, even in the case of very fibrous peats, it has been only possible to reduce the water content to just a trifle below 80 per cent by pressure. The bulk of the water content, therefore, must be removed by other means, and the other means employed always was artificial heat. Such processes employing pressure and artificial heat are absolutely uneconomical, and, under present conditions, it may be accepted as an axiom, that any process devised for the manufacture of peat fuel which depends on the employment of pressure or artificial heat, or both, for the removal of the water content, will inevitably result in failure.

Ekenberg, a Swedish chemist and inventor, who devoted a large part of his life to the investigation of problems connected with the manufacture of peat fuel, considered that the great difficulty with which peat parted with its water content was due to the colloidal substances (hydrocellulose) mentioned before. He therefore attempted chemically so to alter this substance that the residue resulting would, more readily, part with its water by pressure alone. As a result of his study and laboratory experiments, he devised a process called after his name, "Ekenberg Wet Carbonizing Process." The raw peat, containing upwards of 90 per cent water, was submitted to high temperature and pressure in specially designed iron tubes. A chemical change resulted. The material was carbonized, the hydrocellulose was broken down, and a material considerably higher in carbon and of an appreciably higher calorific energy, was produced. But this altered substance still refused to part with the major portion of its moisture through pressure. The bulk of the water still had to be removed by artificial heat. Although several million dollars have been expended on this process by an English syndicate, and about forty thousand dollars more by the Swedish Government, it is today not a commercial success.

Peat, however, is being manufactured economically and on a commercial scale in many of the European countries, and this industry has been expanding and growing more secure, while many in this country have been wasting time and money in efforts to make the manufacture of peat fuel more attractive, from a speculative standpoint.

The only economic process in existence today is that which employs the forces of Nature—the sun and the wind—for the removal of the moisture. The process employing these forces is called the "wet process," and the product obtained is termed "machine peat." This is the process which the Mines Branch, Department of Mines, demonstrated at the Government peat plant at Alfred, Ont.

The "wet process" consists of the following steps:

1st.—The excavation of the raw peat by hand or by specially designed mechanical excavators.

2nd.—The transfer of the excavated material to the hopper of a specially designed macerator.

3rd.—The transfer and spreading of this pulped peat on the portion of the bog prepared for drying purposes.

4th.—The cutting of the spread peat, when sufficiently set, transversely and longitudinally into blocks, which, when dried to about 35 per cent moisture, have the dimensions of the ordinary building brick.

The macerator, which performs, perhaps, the most important function of the entire process, consists of a cylindrical shell, inside of which is set of spiral rotating knives and a set of knives fixed to the inside of the cylinder. The material fed to the hopper is forced by these spiral knives through and against the fixed knives. The fibres, stems, and pieces of wood which are often found scattered throughout a bog, are cut, torn or ground into small fragments, and the peat composing the different layers of the bog and the gelatinous substance, previously referred to, are thoroughly intermixed. This produces a homogenous mass.

The degree to which pulping is carried is determined by regulating the opening of the spout through which the pulped material has to pass.

During the drying stage, the hydrocellulose content of the peat performs a very important function. It serves to bind the particles of the peat together, forming a concrete whole, and prevents the peat blocks from re-absorbing moisture when the drying period is interrupted by wet weather. This waterproofing of the peat block is due to the fact that the colloidal substance forms a skin covering the outside of the

block, and that this skin always assumes a state of complete saturation. Hence it acts as a vehicle for conveying the moisture from the inside of the brick to the atmosphere.

The moisture evaporated from the outside of the block by the sun's heat is immediately balanced by moisture drawn from within. This equilibrium is always maintained until drying is complete.

During rainy weather, the reverse takes place; the rain brings the skin to its maximum saturation, thus preventing moisture from reaching the interior of the block.

The blocks, as the drying proceeds, contract and become denser and more resistant to breakage.

The Department of Mines manufactured, during the two seasons the Government plant was in operation, about 3,000 tons of standard peat fuel. A large part of this production was sold at a nominal price per ton to householders in Ottawa and the towns and villages in the vicinity of the peat plant, for the purposes of introducing this form of fuel, and enabling the Department to form an opinion regarding the favor with which this fuel would meet.

150 favorable opinions regarding the value of this fuel, from those who tried it, were collected by the Canadian Peat Society, and published in their journal.

Cost of Manufacture.

The results of the manufacturing operations conducted at Alfred indicate that, with strict business management, peat can be manufactured for \$1.70 per ton on the field. This figure includes all amortization, charges, such as interest on investment, amortization, etc. The machine employed depended on hand dug peat, and, for an output of 30 tons per day, 14 men all told were required.

The newer plant which was erected on the Government bog after its sale to private parties was equipped with mechanical excavators, spreader, cable-way for transporting pulped peat to drying field, and many other innovations and improvements.

Mr. E. V. Moore, who erected this plant and operated it during the experimental stage, informed me that the results obtained showed that peat could be manufactured at a cost per ton considerably below that obtained with the Government plant.

The conditions prevailing at the time war was declared unfortunately prevented the operation of this plant under thoroughly commercial conditions.

The following is a summary of the properties of peat manufactured as described:

*“Peat is a clean fuel to handle; has, as a rule, a very low ash content, and produces no soot or other deposit when burned in an ordinary cook stove or open fireplace. The ash, moreover, is in a very finely divided condition, free from combustile matter, and can be easily removed from the stove or fireplace. Clinkers are not formed. On account of the ready manner in which peat fuel ignites, often a little paper or a few shavings are sufficient to start a fire. A peat fire does not, therefore, require to be kept continually burning throughout the day, if not needed, since a new fire can thus easily be started when required.

Peat fuel, on the other hand, is more bulky than coal and is of lower heating value per pound. The relation between anthracite coal and peat fuel are regards heating value per pound is 12,500:7,000, or 1.8: 1, that is, one pound of the average anthracite coal is equivalent in heating value to 1.8 pounds of peat fuel, containing 25 per cent moisture. For a definite heating value, therefore, it is necessary to store 1.8 times the weight of the coal required in peat fuel. The volume occupied by the peat fuel, owing to its low specific gravity, will also be much larger than that of coal. One cubic foot of ordinary furnace anthracite coal weighs approximately 56 pounds, while one cubic foot of machine peat weighs about 27 pounds. The volume of peat required to equal coal of the above heating value will, therefore, be about 3.6 to 4 times that of the coal, which is a matter of considerable moment, and introduces serious problems when large quantities of fuel must be stored.”

Peat is an excellent fuel for many of the domestic purposes for which coal usually is used, and can, if certain changes are made in the design of house heating plants, be utilized in general for house heating. But peat possesses certain chemical characteristics which make it specially valuable as a source of nitrogen.

Fuel Requirements of the Pulp and Paper Industry.

The pulp and paper industry of Canada consumed, in 1916, 1,764,912 cords of wood in the manufacture of wood pulp and paper. The quantity of coal consumed by this industry during the same period was, approximately, 1,000,-000—3.5 of a ton per cord of wood utilized. It is interesting in this connection to note that the heating value of the above quantity of wood is approximately equal to 1,412,000

¹From address given by Dr. Eugene Haanel before Conservation Commission, Ottawa, Nov. 27, 1917.

tons of coal, or over 1.4 times the quantity of coal required to supply the required heat for the various operations involved. The above quantity of fuel does not, of course, include the large amount of wood waste, etc., which is burned in most of the mills.

The information required by the pulp and paper manufacturers is: when and at what cost can the required quantity of fuel be obtained, in the event of the present fuel situation continuing for the duration of the war, or what is quite likely, if Canada is forced, at the conclusion of the war, to rely entirely, or nearly so, on her own fuel resources?

Wood pulp mills are distributed throughout the provinces of British Columbia, Ontario, Quebec, New Brunswick, and Nova Scotia; Quebec and Ontario possessing the largest number of mills in active operation. Those mills situated in British Columbia, New Brunswick and Nova Scotia will not be seriously affected by an embargo placed on export coal, if such a measure were carried into effect by the United States, since British Columbia and Nova Scotia possess abundant resources of excellent bituminous coal, while New Brunswick has a limited supply of good coal, which can be augmented by coal imported from Nova Scotia.

The provinces of Ontario and Quebec, especially those parts situated long distances from water transportation, occupy a much less favorable position concerning a continuous and cheap supply of coal.

The pulp mills of Ontario and certain of those in Quebec are dependent on United States coal, which supply, if cut off or curtailed, would very seriously handicap these mills, unless a satisfactory fuel could be obtained at practically the same price as that paid for an equivalent quantity of coal.

Pulp mills situated within convenient distance of the St. Lawrence river and Lake Ontario, also those near the navigable portion of the Ottawa River, i. e., that part of the river navigable as far as Montreal, can obtain their fuel from the Nova Scotia coal mines at a reasonable cost. Such coal could also be distributed throughout large portions of Ontario and Quebec by water, in case the much discussed Georgian Bay Canal were constructed.

Those mills, however, situated so far inland that railway transportation is necessary will either be compelled to pay a higher price, i. e., compared with the cost of coal to those mills more favorably situated with respect to proximity to coal sources or water transportation, or they must de-

crease to the greatest extent the quantities of coal required by utilizing other sources of fuel.

In the case of certain pulp and paper mills, it may be possible to turn to advantage peat bogs lying in their immediate vicinity, or to utilize surplus electric energy in place of coal when large water powers exist in their vicinity.

Peat fuel is being employed in Germany for the generation of power on a large scale through the media of a steam generator and steam engine, with, it is reported, excellent results. The feasibility of utilizing peat fuel for the generation of steam may, in general, be said to depend entirely on the cost at which peat fuel with about 25 per cent moisture can be delivered to the boiler plant. Other very important factors must, however, be considered, viz., the method employed for the burning of the peat fuel under the boiler, and the method of storing the very large quantity of peat fuel for a season's operation, and the feeding of this fuel to the boiler plant.

Except under most favorable conditions, peat fuel cannot be recommended for the generation of steam on a large scale.

The most economic method to employ for the conversion of the heat energy of this fuel into useful work, or into forms of heat energy which can easily and economically be made use of, is the generation of a producer gas suitable for power, industrial, or other purposes.

The high nitrogen content usually found in the peats of this country can, when the peat is burned in a by-product recovery producer, be efficiently recovered in the form of ammonia. The cost of the gas generated can be materially reduced by the sale of the ammonium sulphate manufactured from the ammonia recovered. Producer gas can be employed for the generation of steam in the hot state, if by-product recovery is not contemplated. This method of utilizing a fuel for the generation of steam will result in several economies, viz., the recovery of valuable by-products, the more efficient combustion of the fuel and control in firing, and, finally, the feasibility of using low grade or inferior fuels which are unsuitable for the generation of steam in the ordinary manner.

Electricity as a Source of Heat for the Generation of Steam.

Experiments have been conducted during the past few years to determine the feasibility of raising steam with electric energy. The results of these experiments are not available for general use, but it is quite possible that this method

could be employed with success, wherever electrical power is generated on an extensive scale, and for which there is not a continual demand for the entire quantity generated. At the present time, without all the data on the subject at my disposal, I can only suggest that surplus electric energy which would otherwise not be utilized might be employed in this manner.

In conclusion, I may remark that, as far as cheap supplies of coal suitable for steam generation are concerned, certain of the pulp and paper mills of the provinces of Ontario and Quebec are placed in a disadvantageous position compared with other mills. A large number of the mills, however, are within easy reach of water powers of considerable extent, or of peat bogs. These two sources of heat energy should be utilized to the greatest extent wherever a real difficulty exists in procuring a steady supply of coal.

Mills which are so situated as to be threatened from time to time by a coal famine, and which can not for various reasons make use of electric energy or peat fuel, must depend on wood fuel. The possibility of using wood as a substitute for other fuels is, however, very likely well understood by the manufacturer, and, therefore, requires no further comment.

PEAT FUEL.*

It is significant that at the same time as the British Government should have made up its mind to go thoroughly into the question of exploiting Irish peat the Swedish Government should have found out the best form in which it can be utilized as fuel. Among its various other activities the Privy Council for Scientific and Industrial Research has sanctioned the formation of a committee of the Fuel Research Board for the purpose of inquiring under the following terms:—"To inquire into and to consider the experience already gained in Ireland in respect of the winning, preparation and use of peat for fuel and for other purposes, and to suggest what means shall be taken to ascertain the conditions under which, in the most favorably situated localities, it can be profitably won, prepared and used, having regard to the economic conditions of Ireland; and to report to the Fuel Research Board." So far the weight of experience had shown that for fuel purposes peat could best be utilized by conversion into gas and the gas used for production of power, while certain by-products of value could also, by this means,

*Reprint from Indian Engineering, 1917, Vol. 62, p. 362.

be recovered, such as ammonia, ash and tar. When sun-dried and made into briquettes for combustion under boilers a good average peat has a calorific value of 5,400 B. t. u., which is less than one-half that of ordinary slack; yet a plant employing such fuel has been run in Friesland since 1909 to supply energy to the Ems-Jade Canal and to tramways in Emden and Wilhelmshaven. Why it has not so far been made to pay in Ireland is not clear unless it be that industries in that country are so few and backward as not to be able to afford the capital for the establishment of peat recovery plant. One-seventh of Ireland consists of peat bogs and if these were ever profitably cleared that area of land could come under cultivation just as in Holland, where a similar area of peat land has been cleared and is now being put to agricultural use.

It was a Swedish engineer who first experimented with peat powder as fuel, and we referred in our pages to the apparent success of his work four years ago. Sweden is a land of extensive peat bogs and no coal, and naturally the problem of putting its peat to use instead of depending on foreign countries for coal has long occupied its engineering mind, and now we learn from a paper in "Engineering" that it has been proved beyond question that peat powder can be burnt most successfully on locomotives. Since 1914 a locomotive has been in use specially fitted up for running with this fuel and has been meeting all ordinary traffic conditions satisfactorily both as to operation and cost. In the form of powder the moisture content of peat keeps at from 12 to 15 per cent. and it lends itself easily to automatic stoking. In consequence of this success the Swedish Government voted a grant of 70,000 in 1916 for the purpose of establishing a large factory near Vislanda where there are deposits covering an area of about 500 acres, with an average depth of something over 6 feet. The capacity of the factory is 20,000 tons of peat powder annually, requiring a supply of 220,000 tons of raw peat, so that this area will take some 20 years to exhaust. The peat is raised by three electrically-driven diggers each capable of raising 70,000 cubic meters in a year of 100 working days. Provision is made for subsequent cultivation by leaving a layer of peat undug which is planted over with grass after being dressed off. The diggers load into Decauville trucks which are run out by a motor locomotive to the drying grounds, where the peat is deposited and spread out to the required depth by a specially designed frame run on wheels and

moved to and fro by ropes and electric winches. After spreading, the layer of peat is cut into strips longitudinally and then crosswise, which leaves it in so many rectangular blocks of a size convenient to handle. The blocks are dried only by exposure to sun and air, and when partly dry are turned over. They are next collected into small stacks for further drying till the percentage of moisture is reduced to about 40. At this stage the blocks are trucked into sheds whence they are taken, as required, to the factory. In the factory the blocks are first passed through a course then a fine crusher; next, a screw conveyor takes the crushed peat to drying ovens which are heated with residue from the pulverising process and ordinary air-dried peat, the heating and drying being effected by forcing the combustion gases through a series of brick passages over which lies the peat separated from the passages by cast-iron plates. After drying the peat is moved to the pulverising room by a screw conveyor where it first passes through a sieve in order that so much of it as has already become powder in the process of heating and drying may be recovered. When pulverized it is carried by conveyors to a bunker whence it is discharged into special railway trucks and then carried off to be deposited in bunkers along the line for locomotive use. On the engine tender, above the water tank, is the powdered peat receptacle whence a pipe leads to the locomotive firebox. The receptacle is airtight and kept under pressure within by means of an air compressor worked by a rotary steam engine on the locomotive. This helps to carry the fuel easily along the pipe to the firebox. The powder falls into the firebox at a fairly slow speed and meets there a current of the combustion gases from a small coalfire placed below the inlet pipe. Used in this way the heating value of peat powder is about two-thirds that of coal. In Sweden they already consider the problem of utilizing peat fuel as solved; if it is, there is a good future for Ireland.

PEAT FUEL OUTPUT IN SCANDINAVIAN COUNTRIES.

The output of peat fuel in Sweden in 1916 was 22,500 tons and it is estimated that during 1917 the output will exceed 100,000 tons. Denmark, which produced 200,000 tons in 1916, will have an output for 1917 of over a half million tons. In Norway there are now 217 peat machines working to full capacity. Each of these machines, which cost about \$13,500 and can be worked by two men, will turn out 35 to 45 tons per day.

POSSIBILITIES OF USING PEAT AS FUEL IN SOME PLACES.*

Peat Can Be Used Locally to Insure Against Possible Shortage of Coal.

In view of the dangers of another coal shortage the Director of the United States Geological Survey calls attention to the practicability of using peat as fuel in some localities and offers some suggestions as to the preparation, storage, value, and use of peat.

The time is now ripe to prepare and store peat fuel. Vast deposits of peat that could be converted into fuel are found throughout Minnesota, Wisconsin, Michigan, New York, and the New England States, and in the northern parts of Iowa, Illinois, Indiana, Ohio, Pennsylvania, and New Jersey, according to C. C. Osbon, of the United States Geological Survey, Department of the Interior, who has recently been studying this subject. Many peat beds occur also on the Atlantic Coastal Plain from New Jersey to southern Florida and westward along the Gulf coast to the Mexican boundary. This Coastal Plain is rather remote from the known coal fields and contains few other mineral fuels. The preparation and storage in farming communities and villages of peat fuel taken from these deposits by the owners of small bogs and by citizens' associations for distribution among their members would not only increase the local fuel supply and in many localities prevent a recurrence of the suffering caused by our recent coal shortage, but would release railroad cars that will be vitally needed for other purposes.

Fuel Value of Peat.

Peat, or muck, as this mineral is frequently called, consists of partly decayed plant remains that contain enough carbon to ignite and burn freely when dry. In texture it ranges from a fibrous, imperfectly decayed kind, through progressive degrees of decomposition, to a thoroughly disintegrated type, and varies correspondingly in color from light yellow to jet black.

Peat in an undrained bog contains about 90 per cent of water, which must be reduced to 30 per cent before it can be used for fuel. By thoroughly draining the deposit approximately 10 per cent of the water in the peat may be removed, but the remainder, which is held in microscopic

*From U. S. Geo. Surv. Press Bul., June 19, 1918.

plant cells and minute intercellular spaces, can not be reduced below 70 per cent without drying in the open air or in a heated chamber. Artificial drying, however, requires so much heat in comparison with that obtainable from the fuel prepared by this process, that so far as the United States Geological Survey is aware, it has not proved commercially feasible.

The value of a given deposit of peat as a source of fuel is dependent on many factors, most important of which are degree of decomposition, heating value, and ash content. Coarse-textured fibrous peat makes fuel that is inferior to the black, compact, thoroughly decomposed kind, unless that kind contains a very large proportion of ash. The maximum quantity of ash that is usually considered allowable in peat for commercial use has been placed between 20 and 25 per cent, but if the content of ash exceeds 20 per cent of the total weight of the dry peat it is scarcely worth the labor of production, even for home use. The heating value and ash content of peat fuel intended for domestic consumption may be determined by a simple practical test. A typical sample should be taken from the bog, thoroughly macerated, dried, and weighed. If, when burned in an ordinary heating stove, the heat generated is almost equal to that produced by bituminous coal, and after complete combustion the weight of the ash does not exceed 20 per cent of the weight of the dry peat before burning, its usefulness as domestic fuel is established.

Methods of Preparation.

The season for drying peat begins about April 15, or as soon as the frost is out of the ground, and ends in September, except in the southern peat region, where it is somewhat longer. Present industrial conditions in the United States prohibit the manufacture of large-capacity peat-fuel machines for operation this year, as such machinery, on account of the small demand in this country, has to be specially designed and constructed. It seems, therefore, that peat intended for use next winter will have to be prepared either by hand or by existing machinery that can be readily converted to use for producing peat fuel.

The hand-cut process of preparing peat, which is widely used in Ireland, seems most practicable for the owners of small deposits in the United States. Before this method can be used the deposit must be thoroughly drained and cleared, and the turf removed from its surface. Most bogs of the built-up type—that is, those which were formed by

the deposition of the remains of plants that grow near the ground-water level—can be drained to the bottom by a simple system of surface ditches. Lake bogs, in which the deposit has accumulated below a permanent water level can not generally be drained far below the surface of the peat without incurring great expense, and are therefore not so well adapted to hand digging as built-up beds. However, many lake bogs in the northern peat region, where most of the marshes in which this mineral has accumulated were formed during the Wisconsin or last glacial stage, may be sufficiently drained for peat recovery by means of a short drainage canal connecting the edge of the basin at the lowest level with an adjacent stream.

After the surface of the bog has been cleared the peat is dug in brick form with a special tool called a slane. This instrument, which can be made by a blacksmith, is a narrow spade with a sharp steel lug welded on one side at right angles to the edge of the blade. The blocks of peat range from 8 to 10 inches in length, from 4 to 7 inches in width, and from 3 to 6 inches in thickness, their dimensions depending on the size of the slane. As they are dug they should be removed to the drying grounds and stood on end or placed on covered racks. At the end of about four weeks, during which they should be frequently turned until their moisture content is reduced to about 30 per cent, the blocks are usually ready for storage. As cut peat absorbs water rapidly, great care should always be taken to protect the dry blocks from rainfall. Peat fuel prepared in this way is bulky, easily crushed, and burns rapidly with considerable waste. In heating value it is superior to wood, but it is unfitted for commercial use.

To produce peat fuel of better quality and in larger quantity than is possible by hand, the machine process should be used. This process, which should be practicable for the use of citizens' associations desiring to prepare fuel for distribution among their members, is, so far as known by the United States Geological Survey, the only one that has proved commercially successful in Europe. The machinery for a small plant is simple and could be quickly obtained and easily operated. It consists essentially of an excavator and a macerator. The steam shovel could be used for digging peat from drained deposits; the dipper dredge is well adapted to removing this mineral from undrained deposits. The purpose of the macerator is to grind the constituents of the wet peat into a homogeneous pasty mass, which may be shaped into compact blocks. In principle and form the

latest types of such machines are similar to the pug mill or grinding machine for plastic clay. Many of the experimental plants in the United States have used brickmakers' pug mills, with very slight changes, to grind peat, and they have proved to be well suited for the purpose. These machines may be readily obtained from dealers in clay-working machinery. After being thoroughly macerated the peat should be shaped into blocks as it issues from the machine or spread in a layer, from 8 to 12 inches thick, on the drying grounds and the bricks marked off by hand as the spreading proceeds. When partly dry they are loosely stacked or placed on drying racks and thereafter handled in the same manner as cut peat.

A specially designed and constructed machine must be used for the production of peat fuel for market. Such a machine consists of a receiving hopper attached to a vertical or horizontal cast-iron body, in which revolve one or two knife-armed shafts. These shafts are also provided with spirally arranged flanges for moving the peat to the grinding knives and advancing it to the device for cutting it into bricks of uniform length as it issues from the orifice of the machine. The principal types of peat machines of modern construction are fully described and illustrated in a paper on Peat and Lignite, by E. Nystrom, published by the Canada Department of Mines, Mines Branch, in 1908.

Machine peat that is allowed to dry slowly contracts into dense mass covered by a gelatinous skinlike substance called hydrocellulose. After the moisture has been reduced to about 25 per cent this coating renders it impervious to water, even when immersed. Peat manufactured by this process makes excellent fuel. In heating value a ton of machine peat is equal to about 1.3 tons of wood, seven-tenths of a ton of good bituminous coal, or half a ton of anthracite. Despite the disadvantages of cut peat, air-dried machine peat is well adapted for domestic use. It is clean to handle and burns freely, yielding an intense heat and producing no soot or other objectionable deposit. For open grates this fuel is nearly ideal, and it is said that peat may be burned in the same stoves as coal and wood. However, the best results could probably be obtained by burning it in a stove with relatively small grate openings and a restricted draft.

A detailed discussion concerning the peat deposits of Maine is given in United States Geological Survey Bulletin 376, which, though no longer available for free distribution,

may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 20 cents a copy. General information with regard to the occurrence and distribution of peat in the United States may be obtained from the United States Geological Survey, and advice as to the practicability of draining and using the peat in particular localities can probably be obtained from the State Geological Survey or engineer, the drainage commission, the conservation commission, and similar state organizations.

To meet the demand for specific data relating to the quantity of peat and its suitability for use as fuel or for a fertilizer in this country, the United States Geological Survey has undertaken an exhaustive examination of the New England, Lake, and Atlantic Coast peat regions. Reports describing the areas examined will be issued free as rapidly as they can be prepared.

A full description of the methods of preparing peat fuel is given in Bulletin 16 of the Bureau of Mines, Department of the Interior, Washington, D. C., from which copies of it may be obtained.

IRISH PEAT INQUIRY COMMITTEE.

Among the various commissions and committees which the British Ministry of reconstruction has set up, a special committee has been formed to inquire into and consider the experience already gained in Ireland in respect of the winning, preparation, and use of peat for fuel, and for other purposes, and to suggest what means shall be taken to ascertain the conditions under which, in the most favorably situated localities, it can be profitably won, prepared, and used, having regard to the economic conditions of Ireland, and to report to the fuel research department.

PEAT FUEL AT CROMWELL, CONN.

According to the Hartford Daily Times of May 4, 1918, Andrew N. Pierson, who has greenhouses in Cromwell, Conn., used peat under one of his boilers last winter with forced draft. Since then Mr. Pierson has put a steam shovel at work at the bog; after excavation, the peat is allowed to dry before being carted to a large shed near the boilers. A chute has been constructed from the storage shed leading to the boiler house.

PEAT GAS USED IN NORWAY AS MOTOR FUEL.

An advertisement has appeared in one of the Christiania papers, inserted by the firm of A. S. Brodrene Overaasen's Motorfabrik & mek., Verkstad, Gjovik, Norway, offering for sale motors that can be operated with peat gas instead of benzine or petroleum. The alterations have been made in accordance with a Danish invention that makes it possible to use peat gas as fuel for motors. It is said that several thousands of the motors are being used in Denmark, and that they have met with success. The new system is stated to consume from 1 to 2 kilos of peat (2.2 to 4.4 pounds) per horsepower hour, according to the quality of the peat.—Consular Report.

THE EKENBERG PEAT PROCESS.

Experiments on the treatment of peat by a modified Ekenberg process are being conducted at Chateauneuf, Bretagne, France. According to a paper in Comptes Rendus of September 3, the peat is first compressed in presses of the Mabille or Anrep types to reduce the water in it from about 90 to 60 per cent. The peat is then treated with superheated steam at 160° C. for 25 minutes and then either compressed again or at once dried, which is best done in special chambers, though air drying may be applied. The product which is called turbon, still contains 20 to 25 per cent of moisture, but does not absorb as it would do if the cellulose in the peat had not been destroyed by the steam heat. The calorific value is stated to be raised by 10 per cent over that of dried peat; the turbon yields 61 per cent volatile matter, 36 per cent fixed carbon, 3 per cent ash. With suitable arrangement of the batteries of autoclaves and utilization of exhaust steam, a heat efficiency of from 85 to 91 per cent is claimed to be realized in this process, which can be worked throughout the year. The turbon is fired directly or sent to gas works (with ammonia recovery) or converted into power gas for internal-combustion engines. This last mentioned utilization has so far proved the most satisfactory.—(Jour. of Ind. & Eng. Chem., April 1, 1918.)

Irish Peat Supplies for Power.—The Dublin Local Section of the Institution of Electrical Engineers recently considered the report of the Coal Conservation Sub-Committee on Electric Power Supply, in so far as it affects Ireland. Mr. G. Marshall Harris, manager of the Dublin United (Electric) Tramways, expressed doubt as to ability to raise

Irish coal to compete with supplies from England, but he thought their peat would be nearly as good and cheap as coal for power production. Mr. J. P. Tierney said that one of the difficulties was the cost of acquiring rights to work the peat deposits, and he suggested the Belgian method, by which the State fixed prices and advanced capital to public companies. Mr. L. J. Kettle said that before anything was done there should be a national survey of the power resources of the country.—(Colliery Guardian, April 12, 1918.)

SPHAGNUM PEAT FOR SURGICAL DRESSINGS

The manufacture of surgical dressings made from sphagnum moss for the American Red Cross is at present limited to the Northwestern Division under the direction of Prof. J. W. Hotson of Seattle, Wash., and to a few workrooms in New York City which Major Hartwell has under his supervision.

The particular qualities that are necessary for the sphagnum moss to be of use for surgical dressings are size, leafiness, softness and flexibility, and, of course, absorbency. In general, the number of leaves indicate the amount of water the plant will absorb. Any information readers can give of the location of bogs containing such sphagnum together with the names and addresses of the parties who own the bogs will be appreciated by the editor and the country at large. If possible samples should accompany the information.

Prof. C. O. Rosendahl, of the University of Minnesota, together with our president, Mr. L. B. Arnold, spent several days in the region north of Duluth, and were able to locate quite a number of bogs containing sphagnum of a promising kind. However, by far the greatest amount of sphagnum found belongs to a species which is of little or no use for surgical dressings. One of the party is making further explorations along the north shore of Lake Superior to the western point of the state, and it is believed that some of the best moss will be found within the influence of the lake climate.

HONOR ROLL.

Joseph Hyde Pratt, State Geologist of N. C., Chapel Hill, N. C., Charter President of the American Peat Society—Lieutenant-Colonel 150th Eng. Reg.

Paul H. Todd, of Kalamazoo, Mich., has been with the American Expeditionary Forces in France for several months.

Paul Work, Prof. of the N. Y. State College of Agricul-

ture, Ithaca, N. Y., was recently in training at Camp Lee, Petersburg, Va.

SPHAGNUM MOSS FOR SURGICAL DRESSINGS GATHERED IN NEW BRUNSWICK.

According to a report by the St. John Board of Trade, large deposits of sphagnum moss have been found at Musquash and at Beaver Lake, near this city. This moss, when properly treated, is used for surgical dressings, and is being gathered by girl students under the direction of William McIntosh, curator of the Natural History Society.

This moss is known as the peat or bog moss, the leaves containing abundant aqueous tissue composed of colorless cells. The plants grow only in swamps or in water, where by annual decay they build up layers of peat. Quantities of this moss are being gathered for the hospitals in Europe.

Peat Occurrences in Illinois

Winnebago County.

Deep peat occurs in various parts of Winnebago county, occupying low, swampy areas that have a rather constant supply of moisture. It covers a total of 2.23 square miles (1,428 acres), or .43 per cent. of the area of the county.

The surface soil, 0 to 6 2-3 inches, is a brown to black peat, containing 56 per cent. of organic matter. The other strata differs but little from the surface, except that in some cases sand or silty material is to be found in the lower subsoil.

Drainage is of first importance with this type. This in many cases is rather difficult to secure because tile cannot be laid to good advantage in peat on account of irregular settling and open ditches must be resorted to.

This type is rich in all important elements of fertility except potassium. A thoro trial should be made with potassium salts unless the supply of farm manure is sufficient to provide enough potassium.

In Table 1 are given all results obtained from the Manito (Mason county) experiment field on deep peat, which was begun in 1902 and discontinued after 1905. The plots in this field were one acre* each in size, 2 rods wide and 80 rods long. Untreated half-rod strips were left between the plots, which however, were cropped the same as the plots.

The results of the four years' tests, as given in Table 1, are in complete harmony with the information furnished by the chemical composition of peat soil. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone

*In 1904 the yields were taken from quarter-acre plots because of severe insect injury on the other parts of the field.

produced no increase in the corn crops, either when applied alone or in combination with kainit either the first or the second year.

TABLE 1.

Corn Yields in Soil Experiments, Manitowoc Field; Typical Deep Peat Soil (Bushels per acre):

Plot No.	Soil Treatment for 1902.	Corn 1902.	Corn 1903.	Soil Treatment for 1904.	Corn 1904.	Corn 1905.	Four Crops
1.	None	10.9	8.1	None	17.0	12.0	48.0
2.	None	10.4	10.4	Limestone, 4000 lbs.	12.0	10.1	42.9
3.	Kainit, 600 lbs.....	30.4	32.4	} Limestone, 4000 lbs.	49.6	47.3	159.7
4.	} Kainit, 600 lbs.... }	30.3	33.3	} Kainit, 1200 lbs.	53.5	47.6	164.7
	} Acidulat'd bone, 350 lbs.			} Steamed bone, 395 lbs.			
5.	Potassium chlorid, 200 lbs.	31.2	33.9	Potassium chlorid, 400 lbs.	48.5	52.7	166.3
6.	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1	70.3
7.	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs....	44.5	47.3	
8.	Kainit, 600 lbs.....	36.8	37.7	Kainit, 600 lbs....	44.0	46.0	164.5
9.	Kainit, 300 lbs.....	26.4	25.1	Kainit, 300 lbs....	41.5	32.9	125.9
10.	None	14.9*	14.9	None	26.0	13.6	69.4

Reducing the application of kainit from 600 to 300 pounds for each two-year period, reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

Medium Peat on Clay.

Medium peat on clay occurs in areas similar in location to those of deep peat. It comprises .43 square miles (275 acres), or .08 per cent. of the area of the county.

The surface soil, 0 to 6 2-3 inches, consists of a brown or black peat containing, as shown by a single sample, 52 per cent. of organic matter. The subsurface consists of almost identical material, with an organic matter content of 46 per cent. The subsoil is composed of a silty clay containing 1.6 per cent. of organic matter.

Drainage is the first requirement of this type, and the clayey subsoil is sufficiently near the surface to furnish a very satisfactory bed for tile. If sufficient potassium is not secured from this soil to meet the needs of large crops, that element should be added.

*Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

Medium Peat on Sand.

Medium peat on sand occupies but a comparatively small area in the county, aggregating .27 square miles, or 173 acres. The surface and subsurface soils consist of a brown peaty material, while the subsoil is a drab or grayish sand. The same treatment is suggested as for the preceding type.

Shallow Peat on Clay.

Shallow peat on clay occupies only 51 acres in the county. The surface soil contains 35.2 per cent. of organic matter, the subsurface 21.3 per cent and the subsoil 1.2 per cent.

No limestone was found in this type. The addition of this material may prove helpful. Deep plowing may be resorted to if more potassium is needed in the surface soil. On a similar soil in Ford county deep plowing changed the yield of corn from about 20 bushels per acre to 60.

Peaty Loam on Sand.

Peaty loam on sand is found principally in the low areas along the Sugar and Kiswaukee rivers and Coon creek. The total area is 4.43 square miles (2,835 acres), or .86 per cent. of the area of the county. The topography is flat and the areas are poorly drained. Alkali is abundant.

The surface soil, 0 to 6 2-3 inches, consists of a sandy, peaty material containing 13 to 15 per cent. of organic matter. The composition, however, varies a great deal; in some localities it is distinctly a peat, while in others it runs toward black sandy loam or even black silt loam.

The subsurface soil is usually a brown sandy loam, in many cases containing a considerable percentage of silt. The organic-matter content averages 1.6 per cent.

The subsoil is usually a drab or yellowish drab sand. It varies, however, containing in some places strata of more silty or clayey material.

The first requirement of this type is drainage. Farm manure, preferably quick-acting, such as horse, mule or sheep manure, may be used to correct the alkali condition and to supply potassium, which, tho present in fair amount, may be largely inaccessible because locked up in sand grains. Potassium salts may well be tried if the supply of manure is insufficient.

Black Mixed Loam.

Black mixed loam occurs in the low, swampy, and poorly drained areas in which a variety of soils have been formed and have become so badly mixed that it is impossible to

separate them into distinct types. These areas usually occur in valleys occupied by streams which furnish poor drainage for the lowlands. The term "slough" is generally applied to them. In topography they are flat, and in many of them swampy conditions still exist. The total area is 17.29 square miles (11,066 acres), or 3.35 per cent of the area of the county.

The surface soil, 0 to 6 2-3 inches, contains about 8.5 per cent. of organic matter, or 85 tons per acre, but it varies in this as it does also in mineral constituents. Some areas are peaty, while others may be heavy or even sandy.

The subsurface soil varies in the same way as the surface. It contains about 3 per cent. of organic matter. It usually passes into a drabbish gravelly clay (apparently boulder clay), of which commonly the subsoil consists. Frequently the subsoil contains pebbles of limestone, and alkali is often found in this type.

The surface of this type presents a characteristic hummocky appearance, especially when in pasture. The tramping of stock produces this characteristic.

Clay County.

Deep peat is found in a single small area of only 15 acres where springs abound (Section 3, Township 3, Range 8), and the type represents the accumulation of vegetation formed by the growth of grasses, sedges, mosses and other plants. The surface of the peat is only a few inches above the water level, and as an outlet for adequate drainage could be provided only at great expense (or in connection with an extensive drainage system), the utilization of this area for anything but pasture is quite impracticable at present. The samples show considerable carbonate present, principally as fragments of shells.

This soil contains about 50 per cent of organic matter and more than 20 per cent of limestone. If it could be obtained in dry condition so as to reduce the expense of hauling, it could be used with some profit as a fertilizer on the acid upland soils in the neighborhood, which, as a rule, are also markedly deficient in nitrogen and organic matter. The addition of a small application of manure or some clover turned under would hasten the decomposition of the peaty material and thus greatly increase its value when used as a fertilizer. (It should be noted that the specific gravity of peat soil is only about one-half that of normal soil; and consequently an acre of peat soil 6 2-3 inches

deep weighs, in the dry condition, 1 million pounds, while ordinary soils weigh 2 million pounds for the same stratum.)

McLean County.

A few small areas of deep peat, aggregating 83 acres, are mapped in this county. They occur in low, poorly drained places in bottom land or swamps.

The surface soil, 0 to 6 2-3 inches, is black, generally well decomposed, and contains about 55 per cent. of organic matter. The subsurface is very similar to the surface, but the organic-matter content is not so high, being about 50 per cent. The subsoil is quite variable; in some places it passes into a drab silty clay and in others it is peaty to a depth of 40 inches. It frequently contains shells mingling with the organic matter.

Drainage is of course the first essential for this type. If it does not produce well when drained, trials should be made with potassium.

Deep Brown Silt (Bottom Land).

Deep brown silt loam occurs along the streams, chiefly in the southwestern part of the county. It aggregates 23.88 square miles, or 2 per cent. of the county.

The surface soil, 0 to 6 2-3 inches, is a brown silt loam containing from 5 to 8 per cent. of organic matter. It varies somewhat in physical composition from a heavy phase to one containing sand in sufficient amounts to be called a sandy loam. This latter, however, does not occur in areas large enough to be mapped.

The subsurface soil is similar to the surface except that the organic-matter content is slightly lower, varying from 4 to 7 per cent., and consequently the soil is a little lighter in color. The subsoil is not so dark as the surface and contains local areas of coarse material.

Where proper drainage is secured, this type is very productive. As a rule, where it is subject to frequent overflow nothing else is needed except good farming. Even the systematic rotation of crops is not so important where the land is subject to occasional overflow; but where it lies high or is protected from over-flow by dikes, a rotation including legume crops should be practiced, and ultimately provision should be made for the enrichment of such protected land in both phosphorous and organic matter, and, if acid, in limestone.

INVESTIGATION OF CANADIAN PEAT BOGS.**A. Anrep,****Peat Expert.**

In accordance with instructions, a survey of certain peat bogs was carried on during the season of 1916, in order to determine the extent, depth, and different qualities of the peat contained therein.

This investigation started late in June, when the writer left Ottawa with Mr. F. L. West as a temporary assistant, to perform the field work, which was carried on during July, August and September.

The following statement summarizes briefly the results of the season's investigation.

(1) Farham peat bog, situated about one mile to the east of Ste. Brigitte Station, and about three miles to the west of Farnham.

The larger part of the bog lies in the county of Iberville and a considerable portion in the county of Missisquoi, Province of Quebec; the bog crossing the county line to the southwest of Farnham.

The total area covered by this bog is, approximately, 5,100 acres, with an average depth varying from 5 to 15 feet.

(2) Canrobert peat bog, situated in the county of Rouville, Province of Quebec, about $2\frac{1}{2}$ miles east of Canrobert Station, on the Canadian Pacific railway, and about the same distance west of Angeline Station, on the Vermont Central railway.

The total area covered by this bog is approximately, 2,000 acres, with an average depth varying from 5 to 25 feet.

(3) Napierville peat bog, situated about four miles to the north of Hurrysbury Station, on the Grand Trunk Railway, and about the same distance to the southwest of Napierville Station, on the Delaware and Hudson railway.

The bog lies almost entirely in the county of Napierville, Province of Quebec.

The total area covered by this bog is, approximately, 7,200 acres, with an average depth varying from 5 to 10 feet.

The total area investigated in the Province of Quebec for the season of 1916, comprised approximately 14,300 acres.

MARKET FOR PEAT-CUTTING MACHINERY. (Consular Report.)

The Cork Industrial Development Association, 27 Grand Parade, Cork, desires to be put in touch with American makers of labor-saving machinery for peat cutting. The association states that various peat-cutting machines, chiefly of German origin, are already in use, but with the growing shortage of coal and of labor it anticipates a great expansion in the use of peat-cutting machinery, if such machinery is obtainable. Makers of such machinery are requested to send information concerning their products direct to the Cork Industrial Development Association.

EXTRACTS OF PEATY SOILS.

H. Kappen and M. Zapfe have published an article on Hydrogen Ion Concentration of extracts of Peaty Soils and of Plants which form Peat and Humus (*Landw. Versuchsstatt.*, 1917, Vol. 90, p. 321). Although aqueous extracts of peaty soils have a marked conductivity and contain organic and inorganic substances, the hydrogen ion concentration only slightly exceeds that corresponding with the neutral point, so that soluble acids can be present in traces only. The power of these soils to decompose neutral salts is probably due to an exchange of ions rather than the liberation of free acid. In the case of peat-forming plants, the hydrogen ion is usually higher than corresponds with the neutral point, and the true acidity is marked.

ALPHANO HUMUS COMPANY.

With a capital of \$4,000,000, the Alphano Humus Co. has been incorporated under the laws of Delaware, to engage in the manufacture of fertilizers. The incorporators are John N. Hoff, Boonton, N. J., Richard Sellers, Belleville, Del., and James E. Mantee, Portland, Me.

JOHN K. WIEDMER AT THE FRONT.

John Wiedmer, president of the Wiedmer Chemical Co., of St. Louis, recently read with much pride a letter from a friend concerning his son, John K. Wiedmer of the United States marines. The letter reads in part: "John was up on the firing step shooting away when a shell drops near him. Fragments clip off his bayonet at the barrel of his rifle and knocks it out of his hands, breaking it in various places. He picks one up that was not in

use and keeps on firing." Young Wiedmer's grandfather fought in the French army during the Crimean war and his great grandfather was a veteran in the army of Napoleon I.—(Through Oil, Paint and Drug Reporter.)

Peat for Gas Making, Ott, (Gas World, Vol. 68, p. 41, 1918). Wood and peat, after partial drying, will yield a gas of 336-416 B. T. U., or after removing the CO₂ 450-560 B. T. U. The high CO₂ content is owing to O contained in the fuel, but high temperature carbonization tends to minimize its formation. To improve the product for the consumer a rich gas might be added; coal gas and oil being scarce, acetylene seems the most practical. About 15 vols. to 100 of poor gas would be sufficient, and the spent carbide from the acetylene production would easily form a source of milk and lime to remove CO₂ from the poor gas. Without enrichment wood or peat-gas may be burned with little or no primary air. Wood-gas liquors contain practically no NH₃ but approximately 1 per cent of acetic acid; peat usually gives an alkaline liquor. Tars from both contain from 30 to 50 per cent. of H₂O, are poor in benzene and toluene, but rich in phenols. Wood tars tend to produce stoppages, the heavier woods work best.

Peat for Fertilizer—J. P. Schroeder (U. S. P. 1,254,365 and 1,254,366, Jan. 22, 1918). (A) Raw peat is digested with sulphuric acid, the complex, insoluble proteins of the peat being thereby hydrolysed giving simple compounds, soluble in water and available for plant use. The excess acid is then neutralized by the addition of finely ground rock phosphate. The material is thus obtained in a physical condition suitable for application to the soil. (B) Peat is made slightly alkaline with ammonia and digested under steam pressure, the insoluble proteins being hydrolysed into simple compounds soluble in water. With this material there may then be intimately mixed a small portion of ammonium sulphate and calcium carbonate, which slowly interact and generate ammonia throughout the mass, thus neutralizing any tendency to revert to an acid reaction.

Bacterized Peat—G. H. Earp-Thomas, U. S. P. 1,252,332, Jan. 1, 1918. The product consists of granules of humus inoculated with bacteria beneficial to soil, e. g., nitro-bacteria, and coated with a protective substance, the adherent coating being superficially treated to prevent the granules

from sticking together. An acid or basic mineral fertilizer may be mixed with the coated particles.

Fertilizer. John N. Hoff, New York, N. Y., U. S. P. 1,261,025. 1. The process of making a fertilizer which comprises digesting humus with phosphate rock and acid phosphate to produce reverted phosphate and render the nitrogen of the humus more available, in neutralizing the mass to secure a nutrient medium for bacteria, in digesting a second time, inoculating the mass with bacteria, in drying to reduce the content moisture to between 20 and 30 per cent., whereby a substantial portion of the bacteria are converted into the spore state, and in reinoculating the mass with a suitable bacteria inoculant.

Peat Fuel Manufacture. W. Goodwin & A. Macrae, Br. Pat. 114,026, Mar. 15, 1917. Peat is passed through a crushing mill, similar to that used for crushing sugar cane, to break up the fiber and expel a large proportion of the water, and the resulting thin cakes are passed between rollers maintained at a high temperature by superheated steam or electrical resistances. The peat is then allowed partly to dry in a storage chamber and is subsequently distilled at a low temperature in a series of retorts heated by electrical resistances embedded in the peat, the removal of the remaining moisture being facilitated by the maintenance of a vacuum in the retorts. The products are drawn through the usual condensers and washers to suitable receivers, and any permanent gas passes through the exhauster to a gas holder. The residue is discharged through the bottom of each retort, into a gas producer, where it is converted into carbon monoxide, which may be used for generating steam and also for driving the gas engines which operate the crushing and heating rolls and the dynamos for producing the electric current for the heating resistances. The permanent gas may also be used in this manner. About 8 to 10 per cent. of peat tar is obtained which is converted into motor spirit and heavy oils by fractional distillation, and ammonium sulphate is obtained from the washers.

Wet Carbonizing Process—W. H. Boorne, Br. Pat. 114-603. This invention relates to the wet carbonizing of peat in apparatus of a kind in which steam is employed as a substitute for the hot gases hitherto most generally used. In a general way, but subject to modifications, the carbonizer comprises a main tube in two sections joined together by a suitable coupling such as a threaded collar or flange joint. One of these sections is the main cooling and regenerating

tube, and is fitted as by screwing or expanding into an end plate, say, of cast iron, which may be provided with a door. The cooling tube is surrounded by a preheating jacket for the purpose of regenerating heat from the hot carbonized peat. Between, or adjacent to, the abutting ends of the two sections of the tube, an internal bracket is fitted, and is held in place by the coupling above mentioned. The other or carbonizing section of the tube is to a large extent enclosed in a steam jacket, provided with steam from a boiler, and having in it deflecting plates of any suitable kind for the purpose of ensuring good circulation before the escape of the steam through a suitable outlet. Within the carbonizer section of the tube an inner steel casing of distinctly less diameter is provided, and has one end centered in the bracket above mentioned, whilst the other end extends outside the carbonizing tube and is fitted with a withdrawable bush, or the like, which closes this end of the annular space between the carbonizing tube and the inner casing. The outer end of the inner casing is provided with worm gear, by which it is rotated, and steam is supplied to the inside of the casing by a concentric tube having perforations opening into the casing, the inner end of the said tube being closed. The liquid peat is fed to a preheating jacket around the cooling and regenerating tube, and passes from this by an outside pipe to about the outer end of the carbonizing tube, from whence it is led to the annular space between the inside of the said tube and the outside of the casing therein. The peat passes along this annular space, through the bracket and against a spring-controlled valve, capable of regulation, and adapted to be pushed back by the pressure of the peat, and then escapes through a suitable outlet.

The Nitrogen Distribution in Peat From Different Depths.

By C. S. Robinson and E. J. Miller.

(Reprint of Mich. Agri. College—Tech. Bul. No. 35.)

Peat soil, because of its high content of organically combined nitrogen, affords exceptionally suitable material for the study of organic nitrogenous compounds in soil. Partly on this account and partly because of the importance of this type of soil in Michigan, it was selected some years ago for the purposes of such study in this laboratory. The present bulletin, the experimental work of which was carried on between the summers of 1914 and 1916, is one of the series of reports of the results.

The experiments described herein are based upon the fact that the suggestion, made many years ago¹ that the organic nitrogenous material in soils is largely of protein origin, may be considered demonstrated by subsequent investigations, among which may be included two made in this laboratory.² The present article deals with the application of some of the methods of protein analysis to the study of the nitrogenous compounds in peat.

The objects of the work may be stated as follows:

1. To study the variation in the nitrogen partition in peat with depth or age and state of decomposition.
2. To compare its composition with that of pure proteins, and
3. To determine whether or not any relationship exists between the chemical composition as determined by the above mentioned methods of analysis and the nitrogen availability as determined by the alkaline permanganate method.

Previous Investigations.

The nature of soil nitrogen: Since several reviews of the literature dealing with the organic nitrogenous compounds in soils are already available, it is unnecessary to give a complete one here.³ Suffice it to say that prior to the year 1887, while several authors had suggested the protein nature of soil organic matter, practically but one piece of actual experimental evidence had been offered in support of the as-

1. See in this connection, Mulder, *Jour. Prakt. Chem.* 1844, 203; 321; v. Sivers, *Vers. Stat.* 24, 193 (1880).

2. Technical Bulletins 4 & 7, Mich. Agric. Exp. Sta.

3. See Lathrop, *Jour. Frank. Inst.* 183, 489-498 (1917).

4. *Vers. Stat.* 14, 248 (1871).

sertion. This was reported by Detmer⁴ who showed that a considerable portion of the nitrogen in soils could be liberated as free nitrogen by means of nitrous acid. Although, in the light of modern knowledge this point assumes great importance, it seems to have attracted but slight attention at the time.

In the year 1887, however, three articles appeared which afforded valuable information regarding the nature of some of the nitrogen compounds in soils Boumann¹ found that certain black Russian soils, rich in humus, but containing only traces of ammonia as such, yielded a considerable amount of it upon heating with dilute hydrochloric acid or upon treatment with alkali even in the cold. He pointed out that such conduct might be due to the presence of amino and amido compounds.

Almost simultaneously this subject was taken up somewhat more extensively from this point of view by Berthelot and Andre² in the course of their work on amides. They found that boiling with acids, alkalies or even water split off ammonia from humus. They, too, attributed this to the presence of amides.

A short time later, Warington³ showed the presence of small amounts of aminto nitrogen in a sample of Rothamsted soil which, however, had been heavily manured. He used both nitrous acid and hypobromite in his work.

The presence of any significant amounts of amides was later contradicted by Sestini⁴ who stated that he could remove only small amounts of ammonia by boiling with alkali. He also demonstrated the presence of primary amines by the action of nitrous acid and, as had Berthelot and Andre, suggested the presence of amino acids.

Dojarenko⁵ found considerable quantities of amino nitrogen in some Russian soils rich in humus. Unlike previous investigators he determined the amount quantitatively using Sachsse & Kormann's method as modified by Boehmer.⁶ He extracted the soil with 10% Na^2CO_3 and worked with the humic acid thus obtained. He found from 22 to 70 per cent of the nitrogen in this material to be in the amino form, from 5 to 12 per cent in the amide form while the ammonia varied from 0.78 to 2.36 per cent. He assumed all of the amino nitrogen to be present in the form of amino acids.

1. Vers. Stat. 33, 247 (1887).

2. Compt. rend. 103, 1101; Ann. Chem. 10, 368.

3. Chem. News 55, 27 (1887).

4. Vers. Stat. 51, 153 (1899).

The first attempt to utilize one of the protein nitrogen partition methods for the study of soil nitrogen was made by Shorey⁷ who analyzed humus by means of the Hausmann-Osborne method.

Practically this same method was later made use of in this laboratory for the study of peat by Jodidi.⁸ He showed that, as with protein, a portion of the nitrogen compounds obtained in solution by digesting peat with strong acid could be precipitated with phosphotungstic acid and in several samples he determined in this manner the relative quantities of mono—and diomino acid nitrogen together with the nitrogen obtained as ammonia after digestion, i. e., the acid amide nitrogen.

His work was continued by one of us⁹ who, by the use of Van Slyke's method, was able to determine the actual quantities of nitrogen present in the amino form and to observe the changes taking place during treatment with acids. It was found that only small quantities of amino nitrogen are present as such in peat but that treatment with acid caused the amount to increase, until it reached a maximum at which it remained constant as shown by the following table:

TABLE I.

Hours	Per cent		Hours.	Per cent		Hours.	Per cent	
	Total N.			Total N.			Total N.	
1.0	4.62		11.75	13.27		42.50	25.07	
3.5	7.30		18.00	17.65		90.00	26.17	
6.5	11.32		24.25	20.20		138.00	26.04	

This condition is apparently analogous to that of the hydrolysis of protein bodies.

Several investigators have since studied the problem from this standpoint. Jodidi¹ analyzed several soils using a modification of the same method previously employed by him and a modification of the formaldehyde titration method to determine the actual monoamino and diamino acid nitrogen. He showed that the acid amide nitrogen as determined by him was actually due to the presence of acid amides; that nearly all of the diamino acid nitrogen was derived from diamino acids but that the monoamino nitrogen was only partly composed of nitrogen of monoamino acids. He summarizes his figures as follows:

5. Vers. Stat. 56, 311 (1902).

6. Vers. Stat. 28, 247 (1882).

7. Rept. Hawaii Agrl. Expt. Sta. 1906, p. 50.

8. Tech. Bull. 4, Mich. Agrl. Expt. Sta. (1909).

9. Tech. Bull. 7, Mich. Agrl. Expt. Sta. (1911).

1. Research Bull. 1, Iowa Agrl. Expt. Sta. (1911).

"The acid soluble nitrogen is made up as follows:

Ammoniacal nitrogen, from 1.22 to 1.97 per cent (from 0.99 to 1.14 per cent of the total soil nitrogen);

Nitric nitrogen, from 0.07 to 1.46 per cent (from 0.05 to 1.14 per cent of the total soil nitrogen);

Nitrogen of acid amides, from 25.23 to 33.03 per cent;

Nitrogen of diamino acids from 11.61 to 13.00 per cent;

Nitrogen of monoamino acids from 22.20 to 55.66 per cent.

"The rest of the organic nitrogen consists of compounds other than acid amides and amido acids."

The following statements are also of interest:

"The amount of total nitrogen extracted from the soil of the various plots examined, by boiling with hydrochloric acid, was on the average 75.83 per cent (from 71.12 to 81.20 per cent) the balance (from 28.88 to 18.80 per cent) having remained undissolved." And "There is a marked difference between the organic nitrogen formed in the soil from comparatively fresh organic materials on the one hand and organic nitrogen formed from comparatively old organic materials on the other. While in the first case (Plots E, H, J and N), with the exception of from eight to twelve per cent, the organic nitrogen consists of acid amides, diamino acids and monoamino acids, it contains in the second case (Plots Q and U) a considerable percentage (from 47 to 60 per cent) of compounds belonging to classes other than acid amides and amino acids. These figures refer to the acid soluble nitrogen."

Lathrop and Brown³ applied the Hausmann-Osborne method to the study of soil organic nitrogen but, owing to the fact that they hydrolyzed their soils for only three hours, the results are not comparable with those of the present work.

Shmook⁴ determined the various forms of nitrogen in four Russian soils. Since a complete resume of his data is not available, its significance cannot be discussed.

Potter and Snyder¹ attempted "to correlate, if possible, the amounts of the various chemical groups (1) in the soil with its humic acid, (2) in the soil and its humic acid with the kind of organic fertilizer previously applied to the soil, (3) in the soil and its humic acid with similar groups found in pure proteins; (4) to compare the amounts of amino acid

2. The nitric nitrogen was estimated in water extracts.

3. *Jour. Ind. & Eng. Chem.* 3, 657 (1911).

4. *Zuhr. Opuitu. Agron.* 15, 139. *Abs. Exp. Sta. Rec.* 33, 513 (1915).

1. *Jour. Amer. Chem. Soc.* 37, 2219 (1915).

nitrogen, as such, in the soil with that found by hydrolysis." Their materials were the soils from seven plots which had received various fertilizer treatments, and a sample of peat. They hydrolyzed them with hydrochloric acid and analyzed by Van Slyke's method. Their results are shown in the following table, Table II, the figures for which are in per cents of the total nitrogen.

TABLE II.

Soil.	Extraction reagent.	Amide.	Me- lanin.	Total basic.	Mono- basic.	Non- amino.	gen amino.	Total found	Ex- tra-
101.....	22% HCl	24.09	6.68	10.51	26.17	5.41	72.86	74.02	
102.....	22% HCl	25.61	8.65	11.23	24.62	3.85	73.96	75.12	
103.....	22% HCl	25.61	8.65	11.23	24.23	3.85	73.96	75.12	
104.....	22% HCl	23.0	6.68	7.23	28.11	2.40	67.42	70.93	
105.....	22% HCl	23.38	7.45	7.99	27.21	5.00	71.03	74.31	
106.....	22% HCl	27.21	8.60	11.52	21.28	4.46	73.07	76.47	
107.....	22% HCl	27.20	8.35	10.71	21.01	3.91	71.18	71.31	
108.....	22% HCl	26.64	8.72	12.78	25.22	2.11	65.47	68.68	
Peat.....	22% HCl	18.36	5.95	8.70	31.72	6.15	70.88	71.37	

Among other things they call attention to the high values of the amide nitrogen and the relatively small amounts of basic and non-basic nitrogen in soils as compared with these figures for pure proteins. They suggest as a possible explanation for the large amount of acid amide nitrogen that the synthetic processes may exceed those of decomposition.

Attention may be called here to two investigations dealing with the decomposition of protein material in soil. In 1915 Kelley² added various protein substances to quartz sand, previously treated with a soil infusion and studied the rate of ammonification. He found, contrary to expectations, that the basic nitrogen fraction was more completely ammonified than either the amide or non-basic fraction as shown by the following table: (Table III.)

TABLE III.

Material.	Amide.	Basic.	Non- basic.
Casein	28.57	59.19	28.86
Dried blood	45.53	56.75	42.17
Soy bean cake meal.....	43.06	67.10	48.25
Cottonseed meal	24.37	66.67	15.48
Linseed meal	22.89	37.09	43.63
Cocoanut meal	2.67	21.15	5.00
Globulin from cottonseed meal.....	42.22	50.39	17.48
Zein from maize	19.64	11.63	3.59

2. Bull. 39, Hawaii Agricultural Experiment Station.

The second article referred to is one by Lathrop who studied the decomposition of dried blood in soil, determining the amounts of the various fractions at intervals through a period of about eight months. He found that during the early stages, the amide nitrogen actually increased, then almost disappeared, then increased to a maximum and finally decreased. Its rate and extent of disappearance however were much below those of the other forms. He says "The increase must be considered as being due to the synthetic action of the micro-organisms in the formation of their protoplasmic proteins. In view of the fact that these proteins, in amount, must be much smaller than the proteins of the dried blood, but that the amide nitrogen content of the soil is even greater than the content of the original soil, it would appear that the proteins formed by the micro-organisms must be relatively rich in amide linkings."

The most recent work on the nitrogen distribution in soils is reported in an article by Morrow and Gortner.² These investigators studied the amounts of the various forms of nitrogen in different soil types, using Van Slyke's method. They also supply some data on the results of the hydrolysis of protein material in the presence of large quantities of ignited mineral subsoil.

Their results are partially summarized in the following table (Table IV) taken from their Table VI, p. 324. The figures are in per cents of the total nitrogen.

TABLE IV.

	Sphagnum peat.	peat and sub soil.	Calcare- ous black peat.	"Muck."
Ammonia N.....	23.37	25.52	19.26	19.49
Total "humin" N ³	26.38	26.96	26.07	27.61
Total basic N.....	9.73	10.98	10.60	13.55
Basic amino N.....	5.26	7.29	6.35	9.13
Non-amino basic N.....	4.47	3.69	4.25	4.42
Total non-basic N.....	43.00	38.96	42.40	38.81
Non-basic amino N.....	40.45	33.82	39.46	33.82
Non-amino non-basic N.....	2.55	5.14	2.94	4.99
Total N regained.....	102.28	102.42	98.33	99.46

Those of their conclusions pertinent to the present work are the following:

"Since practically all mineral soils give furfural on treatment with acid it is very likely that a very considerable

1. Soil Science 1, 509 (1916). See also Journ. Frank. Inst. 1917, Feb.-Apr.

2. Soil Sci. 3, 297 (1917).

3. This includes pptd. by $\text{Ca}(\text{OH})_2$ and the insoluble humin N in the soil.

amount of the total humin nitrogen found is due to the presence of carbohydrates in the soil, which give rise to furfural during hydrolysis. This may combine with certain of the nitrogenous compounds and cause an increase in the humin nitrogen, as well as absorb or occlude nitrogenous compounds in the "humin" formed from furfural by polymerization."

"This investigation of the distribution of organic nitrogen in the soil has indicated a new fraction which should be recorded separately. This is the fraction of nitrogen removed from a colorless solution by calcium, iron, and aluminum hydroxides on the addition of calcium hydroxide. The nitrogen retained in this fraction must consist almost entirely of material of non-protein origin, since the organic substances in this precipitate have been shown to be colorless organic compounds absorbed or combined with the metallic hydroxides. This fraction has been reported as nitrogen precipitated by calcium hydroxide."

"The true humin nitrogen remains in the residual soil after hydrolysis, but in addition non-humin nitrogenous compounds are also retained in this fraction."

"Results gained from a study of different soils indicate that the organic nitrogen dissolves during hydrolysis, to almost the same extent regardless of the origin and nature of the soil."

"Some very interesting figures are found in the comparison of the different extracts from sphagnum-covered peat. The portion soluble in sodium hydroxide and not precipitated by hydrochloric acid, gives a nitrogen distribution approximating very closely that of a normal plant protein. The nitrogen dissolving in the preliminary hydrochloric acid leaching shows a nitrogen distribution which is certainly not due exclusively to protein materials, e. g., an ammonia nitrogen percentage of 65.40 and amino nitrogen in filtrate from bases of 17.11 per cent."

"The most significant fact brought out by this study is that the organic nitrogen distribution in different soil types is very uniform. This is to be expected, since it has been pointed out that the nitrogen distribution in soils is an average distribution of all the plant and animal nitrogenous products that find their way into the soil."

The variation in composition of peat: The statement is commonly found that with increasing depth, the carbon and nitrogen in peat increase while hydrogen and oxygen decrease. This idea seems to be one of those fallacious ones which

have occasionally crept into the literature at an early date and been handed down uncorrected through several succeeding generations. Detmer¹ gives data apparently partially responsible for the case in point.² The evidence presented by him is palpably insufficient as a basis for a general statement and the error of the conclusions drawn from it has been demonstrated by the more thorough and accurate work of Zailer and Wilk and Bersch.⁴ These investigators show that the composition of peat deposits does not vary consistently with depth but fluctuates, exhibiting however, a tendency towards the attainment of a maximum value for the carbon and nitrogen and a minimum for the oxygen. This is especially noticeable in the results reported by Zailer and Wilk in their second article referred to above which is entitled "The Influence of 'Vertorfung' on the Composition of Carex Peat." Their results for the four elements under discussion, figured to the ash-free basis are given in Table V.

TABLE V.

Depth of meters.....	0.5	1.5	3.5	5.5	7.5	9.5	11.5
Carbon	56.33	56.68	57.22	58.56	61.39	59.16	57.33
Hydrogen	5.33	5.85	5.55	5.72	5.71	5.82	5.59
Nitrogen	2.35	2.39	2.40	2.58	3.05	2.84	2.69
Oxygen	35.99	35.08	34.83	33.14	29.85	32.18	34.39

In this work the material used had the same botanical composition throughout so that changes in the composition of the peat due to variation in the composition of the peat-forming plants were presumably eliminated. These authors point out that the significance of this factor (the botanical composition of the peat-forming plants) may be considerable and they give a large number of analyses of such plants. They also point out that the state of decomposition does not run parallel to the depth, variations in climate as well as in plant species determining the rate of decay.

Availability: One of the results of the large amount of work done during the last decade on soil organic matter has been the crystallization into a rather definite form of our conception of the term "availability." It has now come to be recognized that the availability of the nitrogen in a given material is almost, though not entirely, dependent upon the ease with which it can be converted into ammonia. It follows directly from this that certain large classes of compounds can be selected, from a knowledge of the properties

1. Loc. cit.

2. See also Welsley Jour. prakt. Chem. 92, 65 Quoted by Clark, Data of Geochemistry.

3. Zeit. Moorkult. u. Torfverwertung 5, 40 (1917); 9, 153 (1911).

4. Ibid. 5, 175; 343; 429.

associated with their chemical constitution, as being easily or difficulty convertible into ammonia, i. e., as being sources or easily or difficulty available nitrogen. Thus the nitrogen of acid amides and amino acids should become easily available while that of cyclic compounds would be classed as quite unavailable. If then some accurate method could be devised which would make possible the quantitative separation of all or even a large part of the organic soil nitrogen into groups of compounds in which the nitrogen occurs in the same form it might be possible to devise a method for determining the potentially available nitrogen; i. e., that fraction of the nitrogen which can ultimately be converted into ammonia as distinguished from that which cannot.

The one laboratory method which has up to the present time come the closest to giving satisfactory results does not deal with individual groups of nitrogen compounds, but, through the action of weak oxidation, attempts to reproduce the results that are obtained in the soil. It has been developed along more or less empirical lines and but little has been done upon its actual value as a means of determining the chemical nature of the compounds involved. Consequently a study of it from this standpoint seemed desirable.

Since another publication is in preparation dealing with the chemistry of availability and the methods for determining it the above brief discussion of the subject will answer the purposes of the present article as its study is not of prime interest in the work herein described.

Experimental Materials.

Two deposits of peat furnished material for the experiments described in the present report.

Deposit No. 1 was located on the right of way of the Michigan Railway Company near Shelbyville, Michigan. At this point a cut had been made opening up a section through a depth of ten feet. Samples were taken every foot in depth starting with the second foot below the surface. They were placed in bags and shipped to the laboratory where they were dried at a temperature of less than 50° C and ground in a mill. The samples used for analysis were further ground by hand in a mortar until all would pass through a sieve having sixty meshes to the inch. They were then further dried at 110° C.

In one respect the deposit was unusual in that it was covered by a layer of soil about ten inches in depth indicating that its origin was not of recent date.

A botanical analysis of the various samples was not

obtained but the following observations were made in the course of the collection of the material which indicate a close resemblance between this deposit and an ideal bog as described by Bersch.¹ The second and third feet² apparently represent the "Hochmoor" stage. While the material as a whole was quite well decomposed, it still showed signs of the original vegetation. The section represented by the sample taken from the fourth foot evidently corresponds to the "Übergangswald" of Bersch since it contained a large quantity of wood, branches and roots of trees as large as six inches in diameter. The section from the fourth to the ninth foot corresponds to the "Flachmoor" section. Through these sections the appearance of the material gradually changed, the peat becoming progressively darker in color and more amorphous in structure as the depth increased. Between the eighth and ninth feet, however there was a marked change in the appearance of the deposit. The material in the last two samples was only slightly decomposed, showing plant remains almost unchanged. The color was a light brown when the samples were first collected but on exposure to air it immediately darkened. It is seemingly a representative sample of "Schilftorf."

Deposit No. II was located a few miles southeast of Flint in Genesee County, Michigan. It is on the border of a small lake which it is gradually filling in and it is typical of many bogs in this state.

The principal vegetation consists of grasses and shrubs. A botanical analysis, made by the late Dr. C. A. Davis of the U. S. Bureau of Mines, may be summarized as follows, the numbers referring to the depth in feet at which sample was taken.

1. Woody peat.
2. Woody-sedge peat.
3. Woody-sedge peat.
4. Sedge-moss peat.
5. Sedge-moss peat.
6. Sedge peat.
8. Sedge peat.
10. Sedge peat.
12. Pond-formed peat.
14. Pond-formed peat.

From this it would seem that any marked change in the composition of the peat due to differences in the compositions

1. Loc. cit.

2. Figures throughout refer to depth below the surface. The sample from the "second foot" was the first one taken.

of the plants forming it would be observed between the tenth and twelfth feet.

Methods of Analysis.

The material from Deposit I was obtained and analyzed some months prior to that from the other deposit and the methods of analysis used in the two cases differ somewhat as will be indicated later.

The ash determinations were made in both cases by burning at low red heat to constant weight.

The total nitrogen determinations were made in both cases by the Gunning modification of the Kjedahl method.

The detriminations of the various forms of organic nitrogen were made in general according to Van Slyke's method but several modifications were necessary to adapt it to the analysis of peat. In all cases triplicate digestions were made and duplicate determinations run on the digestion products, making six estimations on the material from each stratum of the deposit. The details of the method used in the first set of analysis were as follows:

Fifty-gram samples were weighed out in triplicate and digested on the hot plate with 500 c. c. of concentrated hydrochloric acid under reflux condensers for forty-eight hours after which the residues were filtered, washed with hot water and the combined filtrates and washings concentrated to 250 c. c. in each case.

In order to procure as uniform conditions as possible, the digestions were run at one time on a hot plate covered with a thick sheet of asbestos. The flasks were shaken frequently and the heat so regulated that the contents were kept in a state of gentle ebullition.

Owing to lack of suitable apparatus for making vacuum distillations it was necessary to conduct the first concentrations at atmospheric pressure and a corresponding temperature. This may be the cause of small errors in the relative quantities of the various forms of nitrogen. The quantities of humus-like precipitates formed were not very large and in several analysis of the material only small amounts of nitrogen were found. With the exception of the filtrates from the humin determination of the samples from the second foot, all subsequent concentrations were made in vacuo at temperatures below 50° C. Under these conditions, the formation of humus, which always occurred when the solutions were boiled at atmospheric pressure, was avoided.

Ten c. c. samples (1/25) of the concentrated filtrate

from the solid residue were used for the total acid-soluble nitrogen determinations.

The remaining 24/25 of the solutions were used for the determination of the amide and ammonia nitrogen. This was done by making alkaline with milk of lime and distilling the ammonia into standard acid in *vacuo* as described by Van Slyke.¹ Owing to the large volume of solution and the quantity of ammonia it was found necessary to carry on the distillation for several hours. The process was discontinued when ammonia equal to less than 0.5 c. c. 0.1 N sodium hydrate passed over in one hour. The contents of the flask were then washed in the centrifuge. This method was found to be more efficient than filtering and washing on the filter because of the size of the precipitate. The solid material was finally washed into a Kjeldahl flask and the nitrogen content determined.

After being concentrated in *vacuo* to about 500 c. c., each of the filtrates from the humin nitrogen precipitates was treated first with enough concentrated hydrochloric acid to produce a concentration of this ingredient of approximately 5 per cent and then with a solution containing 40 grams of phosphotungstic acid. The flask and contents were then heated on the steam bath till the precipitates had nearly dissolved after which they were allowed to stand for forty-eight hours at room temperature.

At the end of this time the precipitates were filtered off and washed with a solution of 2.5 per cent phosphotungstic acid in 5 per cent hydrochloric acid by means of the centrifuge, a procedure which was found to be somewhat preferable to Van Slyke's first method. A homogenous suspension of the precipitate in the washing solution could readily be obtained by shaking and the separation was usually so complete as to require no further filtering or at most the simple passage of the slightly cloudy liquid through a small filter paper. By running several samples simultaneously, no more time was consumed than by the filtration method. With a four bottle machine, eight samples were run at once, the supernatent liquid being poured from four and fresh washing solution added while the other four were being whirled.

The washing was continued until the washings were free from calcium, a point which was indicated very closely by the change in color of the liquid.

After washing, the precipitates were dissolved in 50 per

1. Journ. Biol. Chém. 10, 20 (1911).

cent sodium hydrate, the phosphotungstic acid precipitated according to Van Syke's directions and the solutions of the diamino acids, containing the "basic nitrogen" fraction, concentrated in vacuo to 250 c. c. Twenty-five c. c. samples were taken for the determination of the "total basic nitrogen." One hundred c. c. portions were concentrated in vacuo to 50 c. c. and ten c. c. samples used for the non-basic nitrogen.

For the second set of determinations the above routine was varied in several particulars. In this instance the micro apparatus was available for the estimation of the amino nitrogen which made it possible to use much smaller quantities of material. Samples weighing seven and a half grams were digested with 75 c. c. of concentrated hydrochloric acid under reflux condensers on the hot plate for forty-eight hours as before after which the solid residues were filtered off and washed with hot water until the filtrates came through free from chlorides. The filtrates were then made up to 500 c. c. and the total acid-soluble nitrogen determined.

Three hundred c. c. portions, corresponding to 4.5 g. of the original material, were used for the subsequent work. The total ammonia in the acid extract, corresponding to the acid amide plus the ammonical nitrogen, was first determined.² The aeration method was used for this purpose as well as for the determination of the ammonia originally present as such in the peat. The apparatus used was similar to that described by Potter and Snyder¹ except that large Drechsel wash bottles were used for purifying the air before it entered the flask containing the sample and quart milk bottles were used as absorption bottles. After experimenting with different concentrations of various alkalis for liberating the ammonia, it was found that the following procedure gave very satisfactory results:

For the ammonia originally present as such in the material, twenty-five gram portions were weighed into 500 c. c. Kjeldahl flasks, 100 c. c. of water added and the flasks and contents shaken until the mixture was homogeneous and no dust remained. The portions adhering to the sides of the flask were washed down with 30-40 c. c. of water and enough sodium chloride and sodium carbonate added in 20 per cent solutions to bring the concentration of the suspensions up to approximately 3 per cent with respect to each of these salts. A few drops of heavy oil to prevent foaming were then introduced into each of the flasks which were connected in the

2. This portion of the work was done by Mr. O. B. Winter.

1. Res. Bul. 17, p. 13, Iowa Aggr. Expt. Sta.

usual manner for aeration. A current of air was drawn through for eleven hours as rapidly as possible without carrying over any of the flask contents. At the end of this period the acid remaining in the absorption bottles was titrated and the ammonia calculated.

For the ammonia in the acid extract, the samples were almost neutralized with a solution of sodium hydrate of known concentration. The quantity of sodium chloride produced in this process was estimated and enough for the solid salt together with solid sodium carbonate added to bring the concentration up to approximately 3 per cent with respect to each salt as before. The rest of the procedure followed was the same as that outlined above except that aeration was continued for only nine hours.

The resulting ammonia-free solutions were treated with calcium hydrate in 10 per cent suspensions for the determination of the humin nitrogen. The solids were filtered off, washed free from chloride and their total nitrogen determined.

The filtrates were neutralized with hydrochloric acid, concentrated to approximately 100 c. c. at 30° in a current of air and transferred to 200 c. c. flasks. After the addition to each of 18 c. c. of strong hydrochloric acid and a solution containing 15 grams of phosphotungstic acid the solutions were made up to 200 c. c., heated till all or nearly all of the precipitates had dissolved and then allowed to stand for forty-eight hours. The precipitates were finally filtered off and washed with a cold solution containing 2.5 per cent of phosphotungstic acid in 3.5 per cent hydrochloric acid until the washings came through free from calcium. The procedure recommended by Van Slyke,² using a small suction filter was followed in this process.

The combined filtrates and washings were neutralized with sodium hydrate, acidified with acetic acid and concentrated at 30° in a current of air until they could be made up to 200 c. c. After having been made up to this volume they were used for the determination of total non-basic and non-basic amino nitrogen. Twenty c. c. samples were used for the former. For the latter, two c. c. samples were used, the desaminization being allowed to proceed for eight minutes.

The precipitates of the bases were suspended in distilled water and nearly or completely dissolved by the careful addition of a 10 per cent sodium hydroxide solution. The re-

2. Journ. Biol. Chem. 22, 281 (1915).

sulting neutral or faintly alkaline solution was in each case transferred to a separatory funnel, acidified with hydrochloric acid and the phosphotungstic acid extracted with ether. The solutions were then neutralized with sodium hydrate, reacidified with acetic acid and concentrated in the manner previously described, to volumes of less than 100 c. c. They were finally made up to volumes of 100 c. c. each and used for the determination of the total basic and basic amino nitrogen. Twenty c. c. samples were used for the former and two c. c. for the latter. In the determination of the amino nitrogen the nitrous acid was allowed to react with the samples for thirty minutes.

"Availability" was determined by the alkaline permanganate method of Jones.¹ The manipulation of this method is as follows:

Transfer an amount of material equivalent to 50 milligrams of water insoluble organic nitrogen² to a filter paper and wash with successive portions of water at room temperature until the filtrate amounts to about 250 c. c.

Dry the residue at a temperature not exceeding 80° C. and transfer from the filter to a 500-600 c. c. Kjeldahl distillation flask (round bottom preferred, but if flat bottom is used, incline at an angle of 30°). Add 20 c. c. water, 15 to 20 small glass beads to prevent bumping, and 100 c. c. alkaline permanganate solution (25 grams pure potassium permanganate and 150 grams sodium hydroxide, separately dissolved in water, the solutions cooled, mixed and made to volume of one liter). Connect with an upright condenser to which a receiver containing standard acid has been attached. Digest slowly, below distillation point, with very low flame, using coarse wire gauze and asbestos paper between flask and flame, for at least 30 minutes. Gradually raise the temperature and when danger (if any) from frothing has ceased, distil until 95 c. c. of distillate is obtained, and titrate as usual. In cases where a tendency to froth is noticed, lengthen the digestion period and no trouble will be experienced when the distillation is begun. During the digestion, gently rotate the flask occasionally, particularly if the material shows a tendency to adhere to the sides. It is recommended that as nearly as possible 90 minutes be taken for the digestion and distillation. The nitrogen thus obtained is the active water insoluble organic nitrogen.

1. Journ. Ind. & Eng. Chem. 4, (1912).

2. Determined by extracting 2 grams of the material on a filter paper with water at room temperature, until the filtrate amounts to about 250 c. c. Determine nitrogen in the residue, making a correction for the nitrogen in the filter paper if necessary.

3. All results are calculated on the basis of ash-free material.

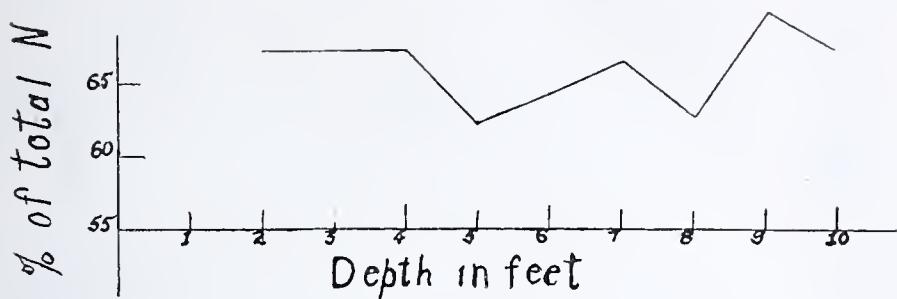


Fig. 1. Acid-Soluble Nitrogen. Deposit I.



Fig. 2. Acid-Soluble Nitrogen. Deposit II.

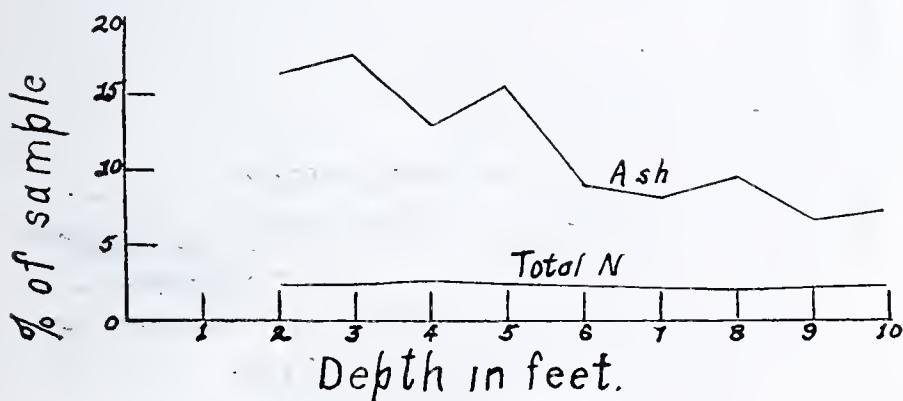


Fig. 3. Total Nitrogen and Ash. Deposit I.

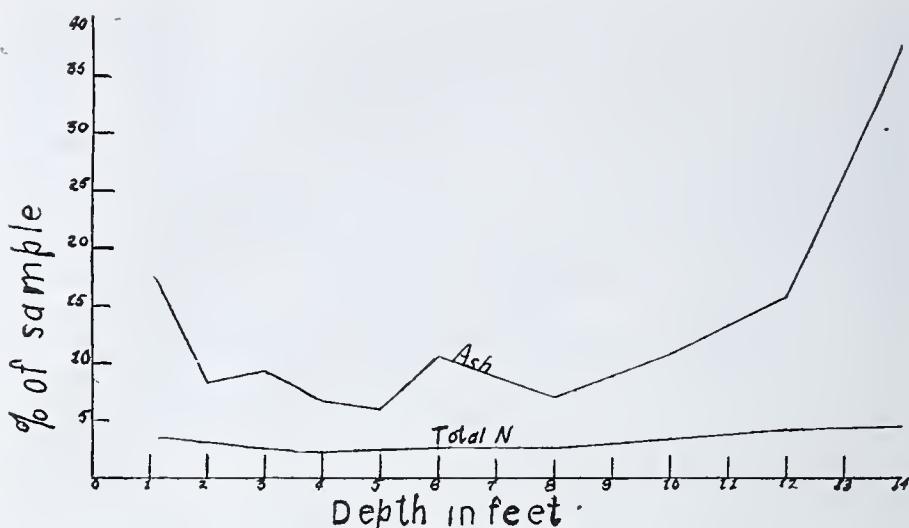


Fig. 4. Total Nitrogen and Ash. Deposit II.

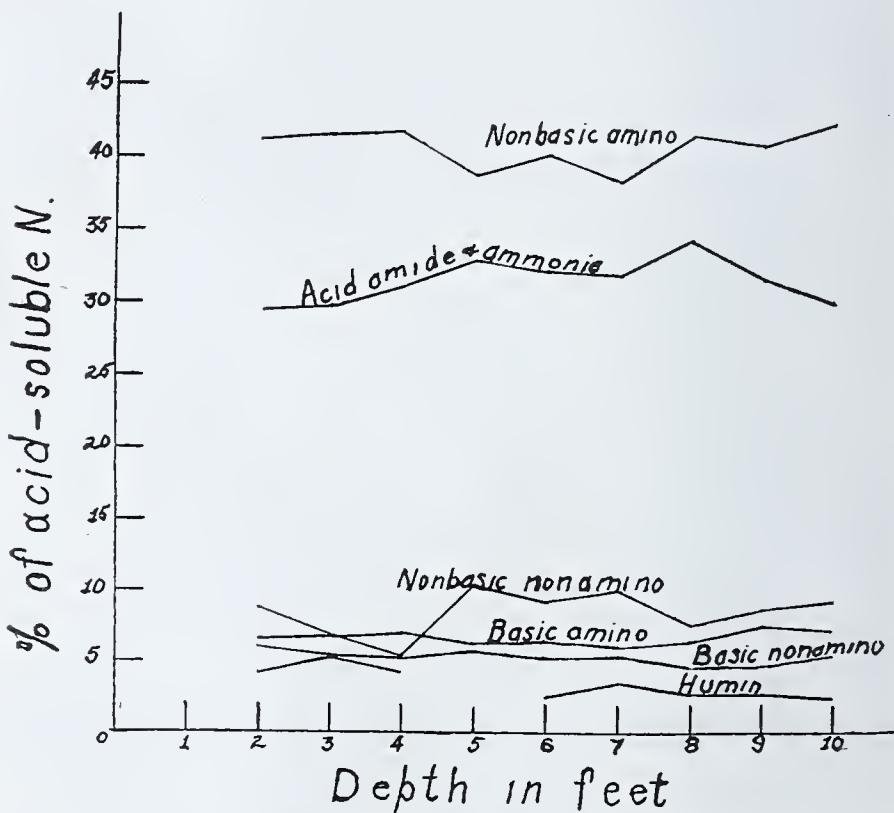


Fig. 5. Nitrogen Distribution. Deposit I.

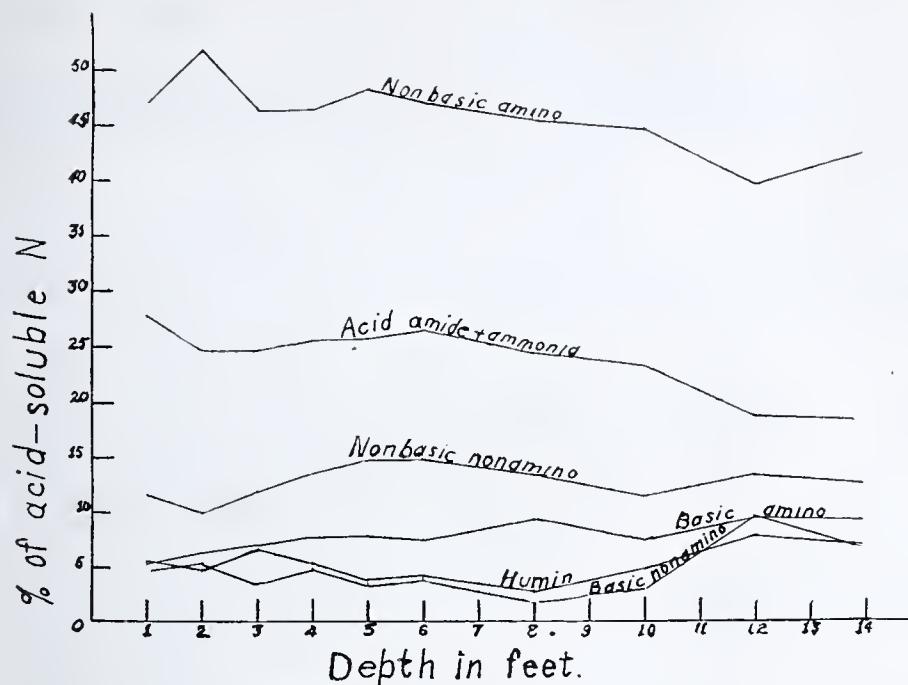


Fig. 6. Nitrogen Distribution. Deposit II.

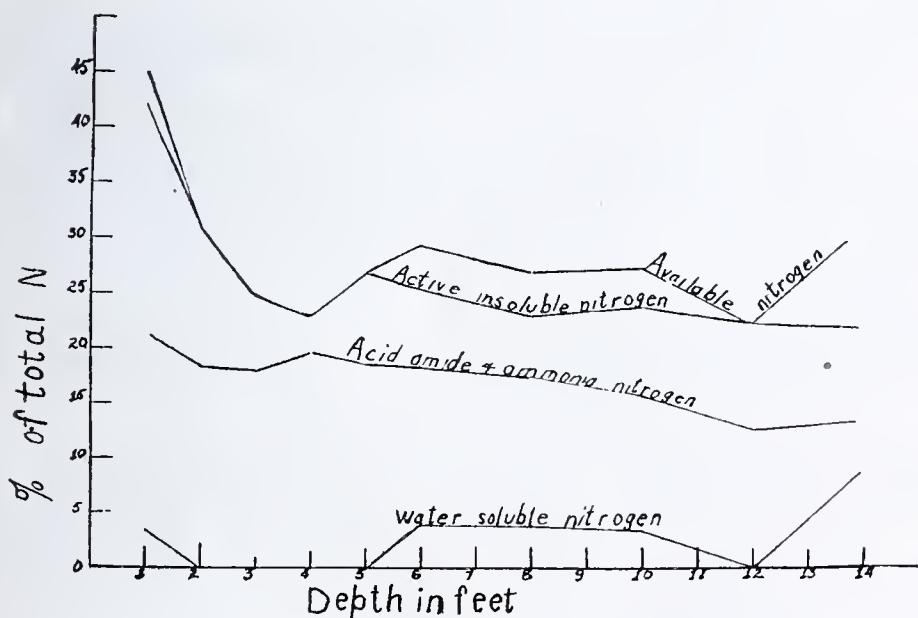


Fig. 7. Availability. Deposit I.

TABLE VI.

DEPOSIT I.

	Ash.	Total N.	Acid Sol. N.	Humin nitrogen.	Acid amide and ammoniacal nitrogen.		Total non-basic nitrogen.	
	Per cent of peat.	Per cent of peat.	Per cent of Total N.	Per cent of Total N.	Per cent of Sol. N.	Per cent of Total N.	Per cent of Sol. N.	Per cent of Sol. N.
2A.....			62.41	2.51	4.02	Lost	30.35	48.63
B.....			62.08	2.57	4.14	18.27	31.45	50.66
C.....			61.92	Lost		18.21	29.47	50.89
Average.....	16.48	2.54	62.14	2.54	4.08	18.26	20.45	31.10
3A.....			63.18	Lost		18.93	29.97	31.11
B.....			61.66	3.17	5.14	18.33	29.73	30.69
C.....			61.66	Lost	(1) 17.81	(1) 28.89	(2)	49.77
Average.....	17.72	2.52	62.17	3.17	5.14	18.63	29.85	30.90
4A.....			62.14	2.82	4.53	(1) 17.73	(1) 28.54	29.70
B.....			61.55	2.39	3.88	19.83	32.32	30.48
C.....			63.33	2.45	3.87	18.92	29.87	30.19
Average.....	12.99	2.75	62.34	2.55	4.09	19.38	31.10	30.12
5A.....			57.15	Lost	(1) 17.86	(1) 31.25	27.97	48.94
B.....			57.94	Lost	18.97	32.74	(2)	.....
C.....			56.68	Lost	18.31	33.31	28.18	49.72
Average.....	15.55	2.62	57.26	.....	18.64	33.03	28.08	49.33
6A.....			59.15	Lost	18.98	32.09	29.55	49.96
B.....			59.63	1.50	2.51	32.40	29.28	49.11
C.....			59.15	1.58	2.67	(2)	.....	.....
Average.....	8.98	2.42	59.31	1.54	2.59	19.15	32.25	29.42
7A.....			62.46	(2)				.....
B.....			61.96	2.13	3.43	19.48	31.44	29.94
C.....			69.78	2.17	3.56	19.68	32.38	29.33
Average.....	8.10	2.27	61.73	2.15	3.50	19.58	31.91	29.64
8A.....			56.35	1.71	3.03	19.83	35.20	(2)
B.....			58.98	Lost	19.75	33.48	29.70	49.52
C.....			57.85	1.64	2.84	(2)	.....	.....
Average.....	9.76	2.08	57.72	1.68	2.94	19.79	34.34	29.70
9A.....			65.90	Lost	20.98	31.84	32.44	49.23
B.....			64.55	2.23	3.46	20.62	31.94	32.59
C.....			64.39	1.55	2.40	20.40	31.69	(2)
Average.....	6.81	2.23	64.95	1.89	2.93	20.66	31.82	32.52
10A.....			63.38	1.55	2.33	19.49	30.75	32.77
B.....			61.87	1.30	2.10	18.17	29.40	32.07
C.....			61.72	1.69	2.73	18.39	29.79	(2)
Average.....	7.40	2.28	62.32	1.51	2.39	18.68	29.98	32.42
								51.77

(1) Low, not included in averages. (2) Solution lost at this point.

TABLE VI.

DEPOSIT I.

Non-basic amino nitrogen.		Total basic nitrogen.		Basic amino nitrogen.		Per cent of Sol. N. accounted for.	Non-amino, non-basic nitrogen.		Basic non-amino nitrogen.	
Per cent of Total N.	Per cent of Sol. N.	Per cent of Total N.	Per cent of Sol. N.	Per cent of Total N.	Per cent of Sol. N.		Per cent of Total N.	Per cent of Sol. N.	Per cent of Total N.	Per cent of Sol. N.
23.93	38.24	8.12	13.01	4.03	6.46	.....	6.42	10.29	4.09	6.55
26.11	42.05	7.88	12.70	3.70	5.95	96.93	5.34	8.61	4.18	6.75
26.65	43.04	7.57	12.22	4.63	7.48	.....	4.86	7.85	2.94	4.71
25.56	41.14	7.86	12.61	4.12	6.63	96.23	5.54	8.92	3.74	6.01
26.71	42.28	7.25	11.48	4.11	6.51	.....	4.40	6.97	3.14	4.97
26.43	42.87	6.72	10.90	4.21	6.83	95.54	4.16	6.90	2.51	4.07
26.57	42.58	6.99	11.19	4.16	6.67	95.69	4.33	6.93	2.83	5.52
26.62 Lo st	42.83	7.07 8.02 7.87	11.38 13.03 12.42	4.66 4.23 3.32	7.61 6.87 6.43	.....	3.08	4.97	2.41 3.79 4.55	3.74 6.16 5.99
26.62	42.83	7.65	12.28	4.07	6.98	95.80	3.50	5.50	3.58	5.30
22.00	38.50	7.06	12.35	3.67	6.42	.....	5.97	10.44	3.39	5.93
22.27	39.29	6.66	11.75	3.35	5.91	.....	5.91	10.43	3.31	5.84
22.14	38.90	6.86	12.05	3.51	6.17	.....	5.94	10.43	3.35	5.88
24.21	40.93	6.96	11.76	3.86	6.51	.....	5.34	9.03	3.10	5.25
23.68	39.71	6.69	11.22	3.62	6.07	95.24	5.60	9.40	3.07	5.15
23.95	40.32	6.83	11.49	3.74	6.29	95.87	5.47	9.22	3.07	5.20
23.34	37.67	7.24	11.69	3.94	6.36	94.89	6.60	10.66	3.30	5.33
23.62	38.85	6.65	10.93	3.48	5.70	95.12	5.71	9.40	3.17	5.23
23.48	38.26	6.95	11.31	3.71	6.03	95.01	6.16	10.03	3.24	5.23
23.56 Lo st	41.81 41.81	6.73 6.03	11.93 10.22	3.72 3.64	6.59 6.17	.....	6.14	7.71	3.01 3.39	5.34 4.05
23.56	41.81	6.38	11.08	3.68	6.38	97.88	6.14	7.71	2.70	4.70
26.88	40.79	7.73	11.72	5.00	7.50	.....	5.56	8.44	2.73	4.13
26.60	41.21	8.50	13.16	5.01	7.76	99.04	5.99	9.27	3.49	5.40
26.74	41.00	8.12	12.44	5.01	7.68	97.04	5.85	8.85	3.11	4.76
26.73	42.18	8.02	12.65	4.70	7.42	97.43	6.04	9.52	3.32	5.23
26.73	43.21	7.71	12.45	4.24	6.85	95.78	5.34	8.62	3.47	5.60
26.73	42.69	7.87	12.55	4.47	7.14	96.69	5.69	9.08	3.40	5.41

TABLE VII.

DEPOSIT II.

	Ash.	Total N.	Acid Sol. N.	Humin nitrogen.		Ammoniacal nitrogen.		Acid amide and ammonia nitrogen.	
	Per cent of peat.	Per cent of peat.	Per cent of Total N.	Per cent of Total N.	Per cent of Sol. N.	Per cent of Total N.	Per cent of Sol. N.	Per cent of Total N.	Per cent of Sol. N.
1A.....			76.88	4.39	5.71			21.33	27.
B.....			76.87	3.67	4.77			21.18	27.
C.....			76.25	4.60	6.03			21.40	28.
Average...	18.40	3.69	76.67	4.22	5.50	0.545	0.710	21.30	27.
2A.....			74.39	4.45	5.99			18.69	25.
B.....			74.39	3.13	4.21			18.22	24.
C.....			74.55	3.24	4.35			18.26	24.
Average...	8.14	3.08	74.44	3.61	4.85	0.749	1.007	18.39	24.
3A.....			73.32	2.89	3.95			17.82	24.
B.....			72.55	6.24	8.60			17.55	24.
C.....			72.35	4.95	6.85			18.56	25.
Average...	9.07	2.66	72.74	4.69	6.47	0.513	0.705	17.98	24.
4A.....			78.30	3.57	4.56			20.29	25.
B.....			77.63	3.94	5.08			19.76	25.
C.....			77.85	4.91	6.30			19.44	24.
Average...	6.61	2.40	77.93	4.14	5.31	0.746	0.957	19.83	25.
5A.....			73.16	3.26	4.45			18.22	24.
B.....			72.76	2.59	3.56			19.27	26.
C.....			72.56	2.79	3.85			18.79	25.
Average...	5.98	2.49	72.83	2.88	3.95	0.803	1.103	18.76	25.
6A.....			69.58	2.58	3.71			18.73	26.
B.....			69.20	2.52	3.64			18.01	26.
C.....			69.96	3.91	5.59			18.37	26.
Average...	10.57	2.76	69.58	3.00	4.31	0.729	1.049	18.37	26.
8A.....			70.93	1.81	2.55			17.36	24.
B.....			72.37	2.29	3.16			17.62	24.
C.....			72.01	2.11	2.92			17.19	23.
Average...	6.99	2.78	71.77	2.07	2.88	0.727	1.013	17.39	24.
10A.....			68.90	3.73	5.42			16.22	23.
B.....			68.44	3.27	4.78			15.71	22.
C.....			69.21	3.05	4.40			15.78	22.
Average...	10.82	3.41	68.85	3.35	4.87	0.513	0.745	15.90	23.
12A.....			68.31	5.69	8.33			12.35	18.
B.....			68.31	5.00	7.32			12.91	18.
C.....			68.49	5.21	7.61			12.91	18.
Average...	15.77	4.25	68.37	5.30	7.75	0.508	0.744	12.72	18.
14A.....			72.52	5.84	8.05			13.58	18.
B.....			72.86	4.28	5.87			13.18	18.
Average...	37.72	4.48	72.69	5.06	6.96	(1)		13.38	18.

(1) Not determined.

TABLE VII.

DEPOSIT II.

Total non-basic nitrogen.		Non-basic amino nitrogen.		Total basic nitrogen.		Basic amino nitrogen.		Per cent of Sol. N. accounted for.	Non-basic, non-amino nitrogen.		Basic non-amino nitrogen.	
Per cent of Total N.	Per cent of Sol. N.	Per cent of Total N.	Per cent of Sol. N.	Per cent of Total N.	Per cent of Sol. N.	Per cent of Total N.	Per cent of Sol. N.		Per cent of Total N.	Per cent of Sol. N.	Per cent of Total N.	Per cent of Sol. N.
44.43	57.79	34.41	44.76	9.30	12.10	4.19	5.45	103.34	10.02	13.03	5.11	6.65
45.46	59.14	36.75	47.81	6.85	8.91	4.67	6.08	100.37	8.71	11.33	2.18	2.83
44.95	58.94	36.95	48.46	7.11	9.32	3.32	4.36	102.36	8.00	10.48	3.79	4.96
44.95	58.62	36.04	47.01	7.75	10.11	4.06	5.30	102.02	8.91	11.61	3.69	4.81
45.40	61.03	37.66	50.63	7.56	10.17	4.40	5.91	102.32	7.74	10.40	3.16	4.26
46.50	62.51	39.33	52.87	8.52	11.46	4.46	6.00	102.67	7.17	9.64	4.06	5.46
46.18	61.95	38.91	52.19	9.49	12.73	5.05	6.77	103.47	7.27	9.76	4.44	5.96
46.03	61.83	38.63	51.90	8.52	11.45	4.64	6.23	102.82	7.40	9.93	3.88	5.22
44.10	60.15	35.51	48.43	9.00	12.28	5.36	7.31	100.69	8.59	11.72	3.64	4.97
38.96	53.70	31.12	42.90	6.60	9.09	4.94	6.81	95.58	7.84	10.80	1.66	2.28
44.38	61.33	34.78	48.08	7.07	9.78	4.87	6.73	103.61	9.60	13.25	2.20	3.05
42.48	58.39	33.80	46.47	7.56	10.38	5.06	6.95	99.96	8.68	11.92	2.50	3.43
45.36	57.93	35.56	45.41	10.41	13.30	5.47	6.99	101.70	9.80	12.52	4.94	6.31
48.33	62.26	36.40	46.89	9.86	12.70	6.83	8.80	105.49	11.93	15.37	3.03	3.90
46.85	60.17	36.97	47.48	8.92	11.46	5.47	7.03	102.90	9.88	12.69	3.45	4.43
46.85	60.12	36.31	46.59	9.73	12.49	5.92	7.61	103.36	10.54	13.53	3.81	4.88
50.21	68.64	36.92	50.47	8.48	11.59	5.93	8.11	109.59	13.29	18.17	2.55	3.48
42.24	58.06	34.37	47.24	7.15	9.82	5.03	6.92	97.92	7.87	10.82	2.12	2.90
45.18	62.27	34.10	47.02	8.48	11.68	6.22	8.57	103.10	11.08	15.25	2.26	3.11
45.88	62.99	35.13	48.24	8.04	11.03	5.73	7.87	103.73	10.75	14.75	2.31	3.16
43.22	62.12	33.45	48.07	8.36	12.01	5.63	8.09	104.75	9.77	14.05	2.73	3.92
44.48	64.27	32.35	46.75	8.67	12.53	5.04	7.29	106.46	12.13	17.52	3.63	5.24
41.32	59.07	32.35	46.24	6.30	9.01	4.73	6.76	99.93	8.97	12.83	1.57	2.25
43.01	61.82	32.72	47.02	7.78	11.18	5.13	7.38	103.71	10.29	14.80	2.65	3.80
42.46	59.86	32.55	45.89	10.08	14.21	7.05	9.94	101.10	9.91	13.97	3.03	4.27
43.32	59.85	31.60	43.67	8.42	11.64	7.65	10.57	98.99	11.72	16.18	0.77	1.07
42.11	58.48	33.91	47.09	5.41	7.52	5.10	7.08	92.79	8.20	11.39	0.31	0.44
42.63	58.72	32.69	45.55	7.97	11.12	6.60	9.20	96.95	9.94	13.17	1.37	1.92
38.66	56.13	31.03	45.05	6.01	8.73	4.70	6.82	93.83	7.63	11.08	1.31	1.91
38.14	55.73	30.83	45.05	7.29	10.66	5.37	7.85	94.13	7.31	10.68	1.92	2.81
39.17	56.59	30.83	44.55	7.93	11.46	5.04	7.29	95.26	8.34	12.04	2.89	4.17
38.66	56.15	30.90	44.88	7.08	10.28	5.04	7.32	94.41	7.76	11.27	2.04	2.96
35.88	52.53	27.33	40.01	12.38	18.13	6.70	9.81	97.07	8.55	12.52	5.68	8.32
36.94	54.07	26.85	39.30	13.91	20.36	5.59	8.19	100.65	10.09	14.77	8.32	12.17
35.83	52.31	27.05	39.49	12.38	18.08	6.79	9.91	96.85	8.78	12.82	5.59	8.17
36.22	52.97	27.08	39.60	12.89	18.86	6.36	9.30	98.19	9.14	13.37	6.53	9.56
40.01	55.17	30.73	42.38	13.06	18.01	7.07	9.74	99.95	9.28	12.79	5.99	8.27
40.57	55.68	31.39	43.09	10.28	14.11	6.19	8.50	93.75	9.18	12.59	4.09	5.61
40.29	55.43	31.06	42.74	11.67	16.06	6.63	9.12	96.86	9.23	12.69	5.04	6.94

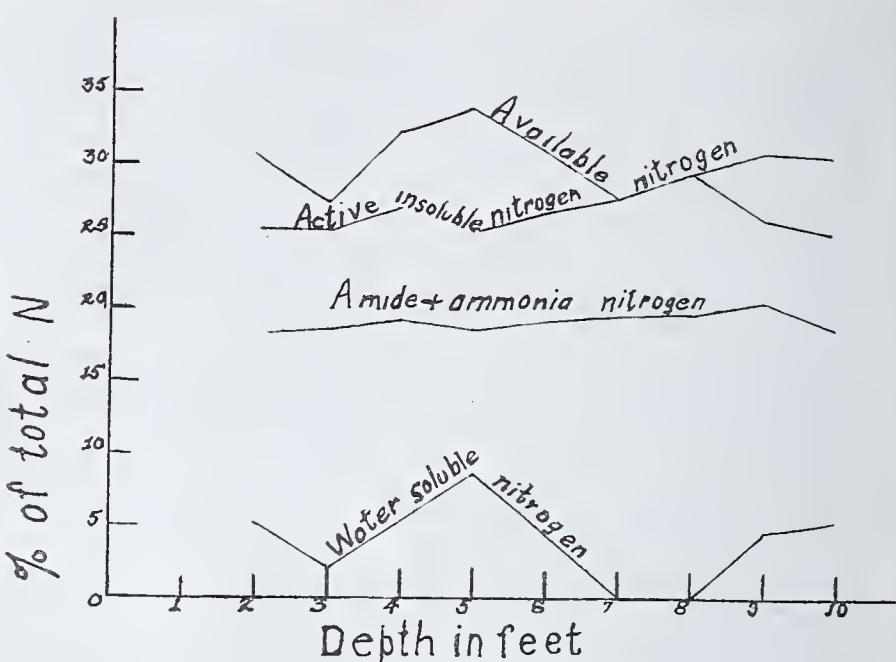


Fig. 8. Availability. Deposit II.

Analytical Data.

The analytical results obtained are given in the tables VI and VII.³ Each of the values shown is the average of duplicate determinations so that the "Average" figures given are the mean of six analyses except where noted. To facilitate comparisons these average figures are also shown graphically in Figures 1 to 8.

Discussion.

The applicability of the Van Slyke method to the analysis of peat: Van Slyke¹ has called attention to the fact that his interpretation of the results obtained by the diazotization method of analysis is valid only when the material under investigation is a pure protein. Such being the case, the usual significance of the various fractions obtained in protein analysis cannot be attributed unmodified to the fractions obtained by the same methods when used on peat, which is by no means a pure protein. The reason for this is that certain compounds, not present in pure proteins, give the same reactions as to the products of proteolysis usually separated in the nitrogen partition method though these non-protein compounds differ markedly in chemical constitution from

1. Jour. Biol. Chem. 10, 17 (1911).

2. Loc. cit.

3. Loc. cit.

those found in protein material. Thus the nitrogen included in the "basic" nitrogen fraction consists, in the case of proteins, of the nitrogen of diamino acids, but with peat it may include the nitrogen of various other compounds precipitable by phosphotungstic acid, such as alkaloids, purine bases, etc. The interpretation to be placed upon the results of Van Slyke's method of analysis as applied to soils has been very thoroughly discussed by Lathrop² and by Morrow and Gortner.³ The latter have pointed out several interesting facts in connection therewith.

The former author after discussing the point in question, says, "It should be clearly emphasized, however, that the method is of decided value, in attacking such a problem as the one at hand, since by the use of such a method it is possible to divide the nitrogenous compounds present in the soil into a number of classes which react towards the various reagents involved in the analytical procedure as though they were arginine nitrogen, histidine, nitrogen, etc. The very fact that a given nitrogenous compound will, towards a given chemical reagent or a series of them, react like arginine, histidine, etc., establishes a chemical and possibly a biochemical relationship."

In brief it may be said that, while the nitrogen distribution method of Van Slyke is of great value in the comparative study of the nitrogenous compounds in the organic matter of various soils, any close comparison with the corresponding groups of pure proteins as regards chemical constitution is impossible in our present state of ignorance of the individual constituents of the groups determined in soils. It must therefore be born in mind that, although the nomenclature of protein chemistry is adhered to throughout this article, it is done so merely as a matter of convenience in indicating the method of determination and not with the idea that the "nonbasic amino nitrogen," for instance, is composed entirely of the amino nitrogen of monoamino acids. Corresponding reservations are made for the other fractions.

The limits of accuracy of the method:—Before passing to a discussion of the figures obtained in the examination of the materials under investigation a brief consideration of their accuracy and of the possible influence of experimental errors upon the appearance of the results may not be out of place.

Experimental errors in this work may be divided into two classes, those due to inaccuracies in the methods of analysis

used, and those caused by one's inability to duplicate the condition of digestion with sufficient accuracy to reproduce hydrolysates of exactly the same composition. Of the two, the latter cause the greater differences in the analytical results.

As regards the errors of the former class, it may be stated that those made in the present work were not above the usual order of magnitude. They would appear in the duplicate determinations of which the figures in Table VI and VII are the averages but which are not published because of the space required by them. The differences in the duplicate titrations in the various total nitrogen determinations approximated 0.1 c. c. of 0.1 N alkali and the readings of the duplicate gas volumes in the amino nitrogen determinations did not, in any case differ by more than 0.1 c. c. in the work on the first lot of material nor by more than 0.02 c. c. in the work on the second lot for which the micro apparatus was used.

The variations due to the second class appear in the lack of agreement between the triplicate samples digested and may be seen in Tables VI and VII. It will be seen that they are not excessive when it is recalled that they represent entirely independent digestions of separate samples of material.

In the columns headed "% of total soluble nitrogen accounted for" are given the sums of the amide and ammonia, humin, total non-basic and total basic nitrogen fractions. These should equal 100 per cent and their divergence from that figure gives an idea of the summation of all experimental errors. Since all of these estimations were straight Kjeldahl determinations the ordinary experimental errors are quite inadequate to account for the variation of several per cent observable in these figures. The fact that the duplicate determinations on each sample agreed as closely as they did makes it seem probable that the trouble is due to some matter of general manipulation. The true cause of the results cannot be given at the present time but the fact that they are not peculiar to the present investigation is evident from an inspection of the work of others.¹

The amount of organically combined nitrogen soluble in hot, concentrated hydrochloric acid: (Figs. 1 & 2). This question has already been discussed by a number of authors.² The quantity of acid-soluble nitrogen varies approximately from sixty to ninety per cent. Such a wide variation is, of

1. See Morrow and Gortner, Loc. cit. p. 324; Osborne, The Vegetable Proteins p. 56 ff. Longmans, Green & Co., 1909.

2. See Morrow and Gortner, Loc. cit. p. 325.

course, to be expected with a number of independent investigators working with materials of different origin and composition and under different conditions of experimentation. As has already been stated, in the present investigation every precaution was taken to secure uniform conditions of digestion. The success of these efforts is attested by the agreement among the triplicates, the maximum variation being only about two per cent while in most cases it was less than one per cent.

No relationship was evident between the amount of acid-soluble nitrogen and the nature of the material nor, in fact, could one be expected since the conditions of digestion were arbitrarily chosen without regard to the nature of the material. That a change in these conditions produces a change in the amount of acid-soluble nitrogen is evident from the following figures which were obtained with material from Deposit I digested for forty-eight and ninety-six hours respectively. The fact that the ninety-six hour digestion in all but one instance gave higher values than those carried on for only forty-eight hours indicates that the shorter period was insufficient to extract the maximum amount possible. This agrees with the results of previous work¹ in which it was shown that nitrogenous material was apparently still being removed at the end of over one hundred hours. From this same work as well as from investigations on pure proteins it is, however, fairly certain that forty-eight hours is sufficient for the hydrolysis of the protein material present and for the production of the maximum amount of amino nitrogen.

TABLE VIII.

Nitrogen extracted from peat in forty-eight and ninety-six hours by hot concentrated hydrochloric acid.

	2.	3.	4.	5.	6.	7.	8.	9.	10.
48 hours	62.14	62.17	62.34	57.26	59.31	61.73	57.72	64.95	62.32
96 hours	65.66	66.58	61.86	62.27	64.42	68.70	66.51	69.31	70.47

The variation in the composition of peat with age and state of decomposition:—

Ash:—The curve representing the mineral content of Deposit I shows a rather regular tendency to decrease with depth, differing radically from the corresponding graph for the second deposit which showed a fairly constant composition for the middle strata with an increase in inorganic material in the top and bottom layers.

Total nitrogen:—The curves representing the total nitrogen contents of the peats at different depths show that

1. Tech. Bul. 7, Mich. Agr. Exp. Sta.

there is no regularity in the variation of this ingredient. In Deposit I the nitrogen increased to a maximum at the fourth foot, decreased to a minimum at the eighth and then rose slightly at the point where the change in the appearance of the material itself occurred. The maximum variation was, however, small, amounting to only 0.67 per cent of the peat.

The curve for the total nitrogen in the second deposit did not in any way resemble the other one. In the second case the total nitrogen content decreased to a minimum at the fourth foot and then progressively increased to the bottom of the deposit. The limits of variation were in this case somewhat larger, amounting to 2.08 per cent of the material.

It is evident from a consideration of these two sets of analyses that no general statement can be made regarding the variation in either the nitrogen or the ash content of peat with depth of the deposit. The high mineral content of the upper layers of the first deposit examined was probably due to the washing in of material from the surface. The high value for the first sample in the second set may have been due to wind blown material or to the difference in composition of the peat-forming material since, as was stated above, the portion of the deposit from which the samples were taken was covered with small trees. The high values for the lowest strata were undoubtedly due to the presence of shells which were quite abundant in the last two samples taken.

Any regularity in the ash contents of peat deposits in general would of course be expected only in exceptional circumstances. The mineral matter in the material would fluctuate with variations in drainage conditions and with the amount of wind blown rock debris carried onto it as well as with the normal variations of the inorganic constituents of the peat-forming plants.

Humin Nitrogen:—While some light has recently been shed upon the chemical nature of the humin fraction obtained in the analysis of pure proteins, its character in the case of peat is still problematical. It evidently consists of two kinds of compounds, those actually insoluble in alkaline solutions and those absorbed by the fine particles of the calcium hydrate. Morrow and Gortner found that the ones they obtained were colorless. In the present work this was not the case, some of the material carried down by the lime being dark colored. It has also been noticed that the acid extracts of peat, filtered through porcelain filters sometimes form dark colored, amorphous precipitates on boiling or upon long standing at room temperatures.

The variations in the humin nitrogen in both sets of experiments reported here are comparatively small, those in the averages for different samples scarcely exceeding the ones between some of the triplicates for the same material. Hence it cannot be said with certainty that they exceed experimental error, while their lack of regularity precludes the drawing of any conclusions regarding their variation with the progress of decomposition of the peat.

These results are rather surprising since it would be expected that the humin nitrogen would increase with the age of the material and its exposure to the elements. Even if the "total humin" nitrogen, i. e., that precipitated by calcium hydrate plus the acid insoluble nitrogen, be considered it will be observed that there is no marked consistent increase with depth.

Ammonia:—As in nearly every investigation of soil nitrogen, the amounts of ammonia present as such in the soils under consideration were so small that any variations in them would be entirely without significance.

Acid amide nitrogen:—This fraction may properly be considered as of the first class in importance because its nitrogen should be quite easily available and consequently the variations might afford some index of the value of the material for plant nutrient purposes. But here again the magnitude of the fluctuations in the various strata approaches with one or two exceptions the limit of the experimental error for separate digestions, the maximum variation in the first set of experiments being about five and in the second set about nine per cent of the acid-soluble nitrogen. The high value in the latter case being due to the last two determinations in the series leaves the main portion of the curve practically a straight line with but slight suggestions of a regular increase and decrease with depth.

All of these variations and especially the large one between the tenth and twelfth feet are probably due to the variation in the chemical composition of the original material as much as to the action of decomposing agents.

Non-basic amino nitrogen:—The remarks regarding the changes of the acid amide nitrogen with depth apply equally well to this fraction. In general the variations are small and do not exceed greatly the ones possible in independent digestions. In the first set of analysis they are irregular but in the second set there are indications of a decrease with depth. There is also a suggestion of parallelism between this curve and that for the acid amide nitrogen.

Non-basic nonamino nitrogen:—The variations in the figures for this fraction are as in the other cases, too small to signify any positive change with the change in depth of the deposit.

Basic nitrogen:—The changes in the curves for both the basic amino and total basic nitrogen are so slight that it is evident no regular variation in these two fractions takes place in the material under consideration. The only chance for any change in composition with respect to these two kinds of compounds is found in the two lowest strata in the second deposit which give rather high results for the non-amino nitrogen. As mentioned above these high values might be due to variations in compositions of the peat-forming plants.

In general the above statements may be summarized by saying that in the two deposits examined there was no characteristic variations in the nitrogen distribution with the age of the material but that some slight ones were manifest due to difference in botanical composition of the peat-forming material. Others were scarcely greater than those unavoidable in making independent digestions. The conclusion to be drawn is in accordance with that of Potter and Snyder¹ and of Morrow and Gortner,² both of whom found but slight variations in soils of different kinds.

From the standpoint of the decomposition of soil organic matter the data presented are of exceptional interest in several particulars. The high content of acid amide nitrogen is a case in point. It is indicative of a signal difference between soil organic matter and ordinary proteins inasmuch as the latter are hydrolyzed with comparative ease and the acid amides then ammonified, while in the case of soil organic matter the complexes in which the soil amides are found are apparently hydrolyzed only with difficulty. Proof of the high degree of resistance to decomposition possessed by these compounds may be regarded as one of the positive results of the present work. Thus in the first set of analyses, if any inference is justified at all, from the variations in the curve, it is that either there was increased formation of acid amides or a comparative stability of the complexes containing them whereby they came to constitute a higher and higher fraction of the residue.³

In the second set of figures there is also a slight tend-

1. Loc. cit.

2. Loc. cit.

3. Owing to the distinct change in the character of the material comprising the last two samples the drop in the curve at this point cannot be construed as the result of age alone.

ency towards an increase in the central part of the curve though the subsequent drop is more regular and hence perhaps more suggestive than in the former case. However, as was pointed out above, these changes are too slight to be more than suggestive and their chief value must be attributed to the fact that they indicate great stability on the part of the material in question.

In this respect the present work agrees with and, in a way, supplements that of Lathrop.¹ He showed that the acid amides in ordinary protein were at first rapidly destroyed but that subsequently they were reformed in very stable complexes which changed but slowly. The present work shows that their resistance is so great that the proportion of the soil nitrogen which they form is not perceptibly diminished for long periods of time.

The nitrogen distribution in peat as compared with that in pure protein:—As has already been stated, the tendency during recent years has been towards the belief that the nitrogenous compounds of soils are more or less closely related to proteins or their decomposition products. While the isolation of individual compounds has shown conclusively that all are not of protein origin, it has demonstrated with equal certainty that a large proportion of them are. Consequently in spite of the fact that the organic nitrogen in peat is not wholly combined in a single protein nor even in a mixture of several proteins a comparison between the two classes of substances is not without interest.²

Several marked differences between the figures for protein and peat are at once apparent. The acid amide and humin contents of the peat are much higher while the total non-basic and basic nitrogen fractions are much lower than the corresponding ones in the protein. That the amino acid nitrogen should be lower is in accordance with what would be anticipated since the agents acting in the soil would tend to destroy these compounds. It would also be expected that the humin nitrogen would be high, but the large values for the acid amide fraction were quite unlooked for since these compounds are as a rule more susceptible to decomposition than amino amides. We should therefore expect them to be rather rapidly and completely hydrolyzed in the soil. The unusual results observed give added interest to the question of the rate and nature of humus decomposition.

It has been suggested by Fischer and shown by Osborne³ that in general there is a distinct connection between the amide nitrogen and the aspartic and glutaminic acid content of proteins, indicating that one of the carboxyls of these

dibasic acids holds an NH_2 instead of a peptid nucleus in the protein molecule. Were such the case in the material under discussion we should expect to find a large quantity of these acids in the split products of humus. Such however is not the case. Glutaminic acid has never been obtained from humic except as a "trace" by Suzuki and aspartic acid has been found only by the same investigator and then in but minute quantities. Apparently then we are dealing here with a situation quite unique, even the suggestion of Bergell and Feigl¹ made to explain a similar instance in certain vegetable proteins, that instead of each molecule of dibasic acid holding one amide group two are united through such a group, does not apply since the relative amounts of dibasic acids are altogether too small. We are then forced to one of two conclusions, either that there are involved dibasic acids as yet undiscovered or that the material is radically different in structure from other proteins.

In either case there are apparently concerned, compounds which in some respects resemble and in others differ materially from acid amides. It would seem that the determination of their actual chemical structure constitutes one of the most important branches of the problem of soil nitrogen conservation and utilization since, until the nature of these compounds now classed as acid amides is known, their utilization must be largely a matter of chance. On the other hand the ascertainment of their true chemical nature might give the opportunity for the development of a process for rendering useful what would theoretically be the most readily available portion of the nitrogen fraction.

Availability:—The availability of organic material may be defined as the ease and extent to which it can be ammonified. Such a definition, while not absolutely accurate since certain organic compounds may serve as plant nutrients, still represents the situation as a whole. Consequently the determination of the availability of a substance resolves itself into the determination of its relative ammonia-producing power.

As is well known, certain combinations of nitrogen under laboratory conditions will produce ammonia more readily than other combinations, acid amides for instance ammonifying generally with greater ease than amino acids and certain types of the latter forming ammonia easier than

1. Loc. cit.

2. Discussions of this topic may also be found in the articles of Lathrop and of Morrow and Gortner already referred to.

3. The Vegetable Proteins, p. 61. Longmans, Green & Co. (1909).

4. Zeit. Physiol. Chem. 54, 258 (1908).

others. Experiments have demonstrated that this also holds true in the soil, e. g., Jodidi's work on amino acids and acid amides as sources of ammonia in soils.¹ Lathrop's work likewise shows that acid amides decrease rapidly in the soil at first. However they later increase and apparently become fairly stable. The present work shows that in peat they are extremely resistant to decomposition. The question now comes up, What is the availability of these resistant acid amides and amino compounds and how can it be determined practically?

While several methods have been proposed for accomplishing this in the laboratory the one in most common use is the so-called alkaline permanganate method, the details of manipulation of which have already been given. A study of this method from the standpoint of its action on various classes of chemical compounds seems never to have been undertaken and under the present work constitutes a part of a more extensive investigation along these lines which is being conducted at the present time in this laboratory.

From a consideration of the underlying chemical reactions involved in the action of boiling alkaline permanganate solution upon the compounds contained in peat, we should expect that the "active insoluble" nitrogen would include a large portion of the acid amide nitrogen and a variable fraction of that present in the form of amino acids, the amount of ammonia obtained from both sources depending upon the ease of hydrolysis of the particular individuals present and the conditions of the experiment. Since a complete hydrolysis of any one group of compounds present is probably never secured under the prescribed conditions, it is not to be expected that the results obtained will coincide exactly with any of those obtained for any particular class of compounds by the more accurate methods used in the estimation of individual groups.

The results with the alkaline permanganate method together with the amounts of nitrogen present as acid amides are shown in the following table, (Table VIII) and the corresponding figures. The values are calculated in percentages of the total nitrogen of the ash-free peat. They show the above statements to be true, the values for the active insoluble nitrogen lying somewhat above those for the acid amide nitrogen which may perhaps be assumed to constitute the bulk of this fraction. In both sets of materials examined there seem to be slight indications of parallelism between

1. Research Bul. 9, Iowa Agr. Exp. Sta. (1912).

these two curves but the variations in each are, in general, so small that they are of little significance, the only marked exception being found in the first two points of the second series. The shapes and relative positions of the curves exhibit a satisfactory agreement with what might be expected from a priori considerations of the chemical reactions involved.

As in the other cases discussed, there is apparently no regularity between the availability as determined by the alkaline permanganate method and the age of material.

TABLE IX.

	Soluble N.		Act. Insol. N.		Available N		Amide NH ₂ N.	
	I.	II.	I.	II.	I.	II.	I.	II.
1.....	.....	3.25	.....	42.02	.....	45.27	.....	21.30
2.....	5.12	0.00	25.59	30.84	30.71	30.84	18.26	18.39
3.....	1.99	0.00	25.40	24.80	27.39	24.80	18.63	17.98
4.....	5.34	0.00	27.01	22.93	32.35	22.93	19.38	19.83
5.....	8.79	0.00	25.19	26.92	33.98	26.92	18.64	18.76
6.....	4.13	3.98	26.86	25.34	30.99	29.32	19.15	18.37
7.....	0.00	.....	27.75	.....	27.75	.....	19.58	.....
8.....	0.00	3.95	29.33	22.98	29.33	26.93	19.79	17.39
9.....	4.78	.....	26.01	.....	30.79	.....	20.66	.....
10.....	5.27	3.52	25.00	23.76	30.27	27.28	18.68	15.90
12.....	.....	0.00	.....	22.12	.....	22.12	.....	12.72
14.....	.....	8.93	.....	21.87	.....	30.80	.....	13.38

CONCLUSIONS.

The results of the investigations reported in the present article seem to warrant the following conclusions:

1. There is no regularity in the variation of total nitrogen and ash contents with the depth of the deposit, the fluctuations being determined rather by the conditions of formation and the composition of the peat-forming vegetation.

2. The amounts of the larger groups determined by the Van Slyke method do not consistently show a regular increase or decrease with depth and, where the botanical composition of the peat-forming plants was approximately constant, they showed no variations in quantity above those ascribable to experimental errors in their determination.

3. It follows from (2) that the organic nitrogenous material is extremely resistant to decomposition under the conditions in a peat deposit and it must be regarded as a possibility that the constitution of some of the components of some of the groups, notably those included under acid amides, differs radically from those usually attributed to these compounds.

4. In comparison with ordinary proteins, peat contains a larger percentage of acid amide and humin nitrogen and a smaller amount of basic and non-basic nitrogenous compounds.

5. The available nitrogen as determined by the alkaline permanganate method did not show any regular variation with the depth of the deposit. In quantity it somewhat exceeded the acid amide nitrogen with which it seems to give slight indications of being associated. Owing however to the lack of any distinctive form in the curves no certain relationship could be demonstrated.

Mr. Chas. Knap, Secretary,
American Peat Society,
Whitehall Building,
New York City.

Dear Sir:—

I, the undersigned, being interested in the development of our peat resources and in the welfare of the peat Society, beg to make application to membership in your Society, for which I enclose \$5.00 as annual dues.

Signed _____

Address _____

Date _____

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Sphagnum as a Surgical Dressing

John W. Hotson, *Superintendent of Moss Dressings,
Northwest Division of the American Red Cross,
University of Washington, Seattle.

Introduction.

The truth of the old adage that "necessity is the mother of invention" is particularly noticeable in times of great emergency such as is now stimulating the thought of scientists the world over. It is the present war emergency that has occasioned the original thinking and inventiveness that is seen in the extraordinary recent development along certain lines of chemistry, aeronautics, submersibles, etc., to an extent never thought possible.

In no less striking manner has this same ingenuity been seen in the marvelous skill and proficiency of surgery, not only in the method of treatment of wounds, which has been astounding, but also in the material used for dressings. War had been declared only a few months when it was seen that there was likely to be a shortage of absorbent cotton, and in an effort to avert such a calamity experiments were begun with a kind of moss known as Sphagnum, or peat moss, as a substitute. At the present time surgical and non-surgical dressings made from Sphagnum are being used in the war hospitals, not only in Great Britain, but in France, Malta, Alexandria, Salonika, Italy and Palestine—practically on all the allied fronts.

* By permission of Prof. Hotson.

Distribution of Sphagnum.

Sphagnum is widely distributed throughout the world. All the species are low plants which are differentiated into stem, branches, leaves and rhizoids or root-like structures. There are no true roots such as are found on higher plants. This moss grows in abundance in low, marshy, undrained places, especially in and around cranberry bogs, but it may occur in other than swampy locations. It thrives best, however, in the damp, humid climate of the colder parts of the temperate zone in Europe, Asia and America. Sphagnum is found abundantly on the moors of Scotland and Ireland, and also in the countries surrounding the Baltic Sea, where the land is low and in general has an excessive amount of moisture, producing a very humid atmospheric condition.

In North America it occurs most commonly along the northeast coast from New England to Labrador, and along the northwest coast from Oregon to Alaska. In the interior of North America large bogs also occur, especially in the region of the Great Lakes. These bogs, however, are gradually being drained, but considerable desirable moss may yet be found in certain localities. There are large numbers of Sphagnum bogs in western Washington, especially along the Pacific coast. It is estimated that there are 25,000 acres of cranberry bogs in this region.

Structure of Sphagnum.

The leaves of Sphagnum are always arranged spirally about an erect stem and its branches. They do not have veins as do those of higher plants. They consist of a single layer of cells, some of which are green and others colorless. The cells that contain the green color are small, narrow and elongated, while between them occur much larger and longer empty cells, whose function is the absorption and storage of water. Consequently the surface of the leaf (Fig. 5) has the appearance of a network, the elongated, green cells forming the net and the large, empty reservoir cells the meshes. Since the leaves are only one cell thick (Fig. 6), these empty cells extend from one side of the leaf to the other, so that if there is any water available it could enter both sides of the cells, thus making the absorption fairly rapid and complete. More-

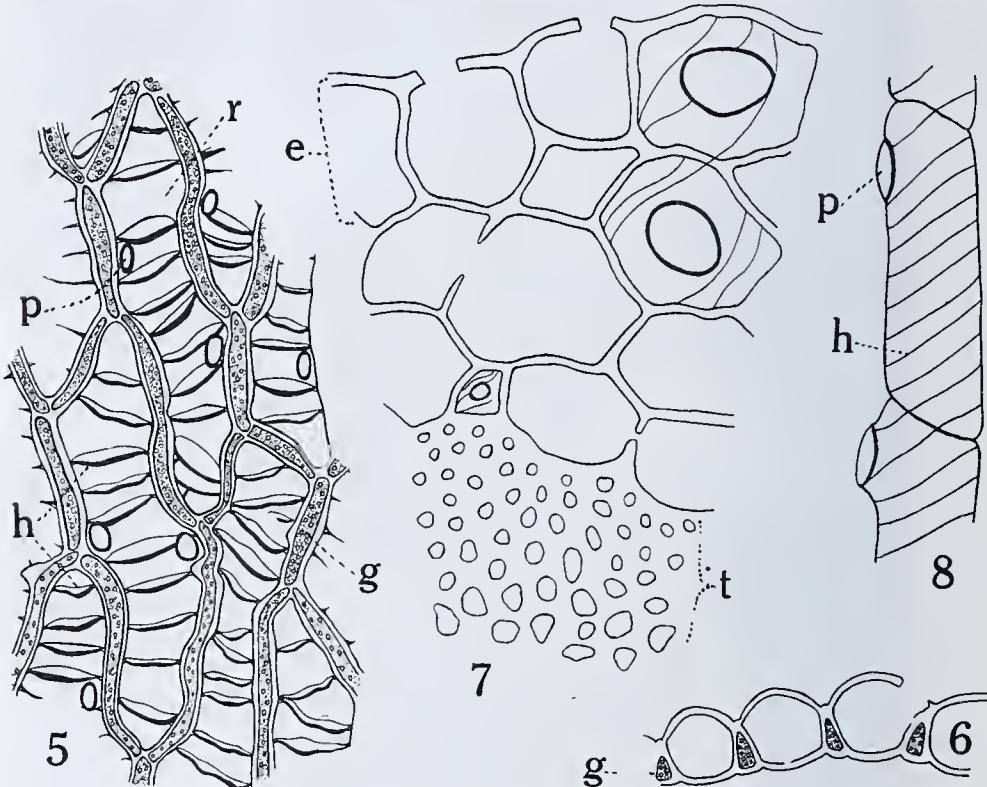
¹ The writer wishes to acknowledge his indebtedness to Prof. T. C. Frye for the photographs used in Figs. 1 to 4; to Prof. G. B. Rigg for those in Figs. 9 and 10; to Mr. G. H. Martin for those in Figs 12 to 17 inclusive; to Miss Agnes Carlson for the drawings in Figs 5 to 8; and to the Northwest Division of the Red Cross for Fig. 11.



Figs. 1 to 4.

Photographs of four species of *Sphagnum*; the first two are suitable for surgical dressings, the last two are not.¹ 1, *Sphagnum imbricatum*. 2, *Sphagnum palustre*. 3, *Sphagnum recurvum*. 4, *Sphagnum fuscum*. Natural size.

over, there are small openings in these empty cells (Fig. 5, p), some on one side of the leaf and some on the other, to allow the water to pass in. These cells are strengthened by transverse thickenings (Fig. 5, h), forming a sort of band or hoop-like structure that prevents the cells from collapsing. The openings leading into the large cells are merely capillary in size, so that when once the water enters it does not readily come out unless some pressure is exerted. Similar absorbent cells, often retort-shaped, occur in the outer cortex of the stem (Fig. 8). They are also devoid of protoplasm, and often have open communication with each other and the outside



A. Carlson, Del.

Figs. 5 to 8.
Sphagnum palustre

e, epidermis

g, green cells, containing chlorophyll

h, hoop-like bands

p, pores or openings into the reservoir cells

r, reservoir cell

t, thick-walled cells that constitute the wiry center of the stem

Fig. 5. Surface view of a portion of a leaf. x 300.

Fig. 6. Part of a transverse section of a leaf. x 275.

Fig. 7. Part of a transverse section of the stem. x 300.

Fig. 8. Reservoir cells from the epidermis of a branch. x 225.

by means of small capillary pores similar to those of the leaf (Fig. 8, p.). It is these large empty cells in the stem and leaf that serve as reservoirs for holding and conducting water. Their effect is like that of a sponge, thus making these plants valuable for surgical work. The leaf, however, is the main organ of absorption and the part of the plant that is the most valuable for surgical dressing. Every precaution therefore

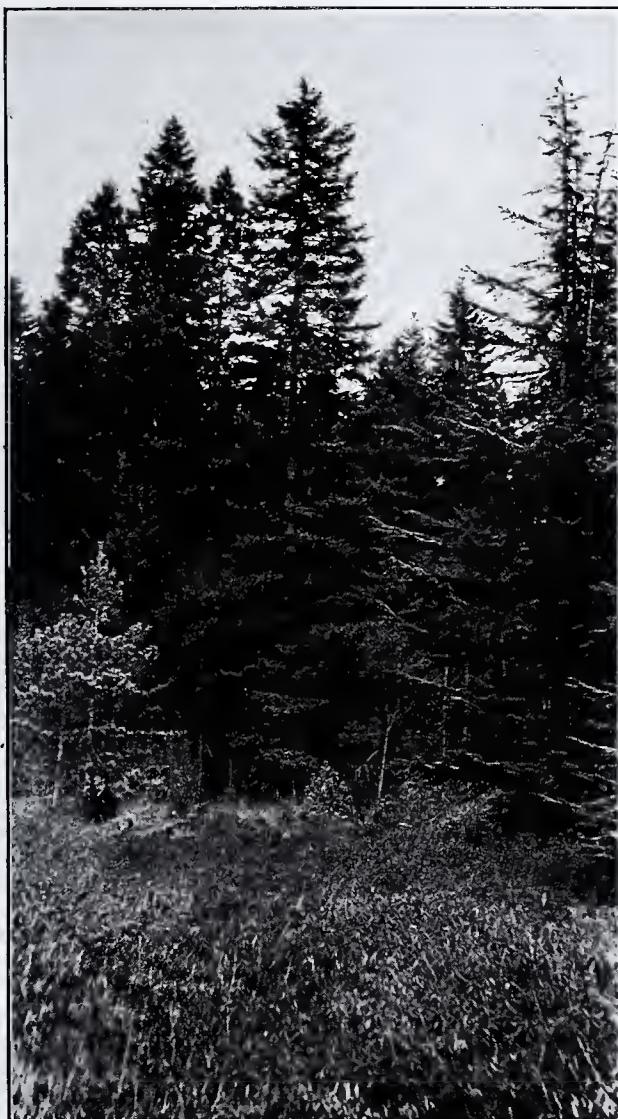


Fig. 9.

A typical peat bog. In the foreground is Sphagnum, Labrador tea, cranberry and swamp laurel. In the background are conifers with certain deciduous shrubs between.

should be taken to prevent any loss. The leaves are very minute and mostly on the clustered lateral and terminal branches. Some of these branches hang down and adhere closely to the side of the stem, others are horizontal, while those at the top of the stem range from almost vertical to horizontal and form a more or less rosette structure (Fig. 4).

Sphagnum Bogs.

The term "Sphagnum bog" is applied to a low, marshy place in which peat moss and usually certain evergreen shrubs are growing. The brown, fibrous peaty bog material often extends several feet deep. It is readily distinguished from a common swamp by the presence of Sphagnum. Many of the bogs in Washington are found in clear open spaces in the dense forest, with or without an open lake in the center. In Alaska, however, they are frequently found on treeless plains.

On examination of a typical Washington Sphagnum bog, one may observe in the center Sphagnum mixed with cranberry (*Oxycoccus oxycoccus*), swamp laurel (*Kalmia polifolia*) and Labrador tea (*Ledum groenlandicum*). Around the margin, just outside the area where the Sphagnum grows and usually a little lower and consequently wetter, may be found willow, alder, aspen, wild crab, hardhack, etc.; while conifers fringe the high ground. This condition is nicely illustrated in Fig. 9, which is a photograph taken from the center of a typical bog.

Stunted hemlock and even Douglas fir are occasionally found out in the bog, but they never seem to thrive. Frequently a pretty little flat plant, often reddish in color, called the sundew (*Drosera rotundifolia*) is found among the Sphagnum. It is interesting because it is insectivorous, obtaining most of its food from captured insects. It is interesting to note that the flora of peat bogs, at least those of western Washington, is almost entirely xerophytic, that is, "the plants characteristic of these bogs show such structural character as we would expect in plants growing in dry places, in spite of the fact that the substratum in which they grow is wet."²

The bog water is usually acid. This acidity tends to inhibit the growth of certain bacteria. Although this is true, bog waters as a rule are not very strongly antiseptic. Large numbers of bacteria have been found in peat bogs by different investigators, but no pathogenic forms have ever been reported. This, however, has little bearing on the usefulness

² George B. Rigg. A summary of bog theories. *Plant World*, Vol. 19, pp. 310-325. 1916.

of the moss for surgical dressings, since these are all sterilized before being used. The point of interest is that there is absolutely nothing harmful present that sterilization will not remove. True, some species, as has been said, produce coarse, wiry stems which, if used, might penetrate the pad and cause irritation of a wound. Such material, however, is not only not recommended for surgical pads but is constantly rejected. It has been demonstrated, also, that there is a toxic substance in bog water that affects plants, preventing some, like the common Wandering Jew (*Tradescantia*) from developing root-hairs and possibly to a limited extent inhibiting the growth of bacteria.

Uses of Sphagnum.

Sphagnum is frequently called "peat moss" because it, with other plants growing in undrained bogs, eventually make peat, which is used extensively for fuel in some countries. Sphagnum is very commonly used by nurserymen and others for packing, especially is it desirable about the roots of plants when moisture is required for a considerable length of time. A number of varieties of orchids thrive as well in Sphagnum as in their native haunts. The moss makes an excellent insulator, much better than sawdust or even cork, but of course it cannot be used where it is exposed to moisture. It excels sawdust as a medium for packing and shipping raw fruit, like grapes, because when one bunch "goes bad" the moss immediately absorbs the moisture and prevents the infection from spreading. In Sweden some of the coarser kinds of paper, like wall paper, wrapping and building paper, are made from this moss. It is used in Alaska and other places where it is abundant to bind up wounds of domestic animals, particularly when there is some discharge. In such cases the moss is applied directly to the wound. When dried it is often used for bedding for horses and other animals. This moss has been used in Scotland and in Ireland as a home remedy for absorbing the discharge from boils or other suppurating wounds. The American Indians made use of dried Sphagnum for diapers for their babies. In Alaska they still do it. More recently it has been used for surgical dressings. This is not entirely the outcome of the present war, although the perfecting of such dressings and their extensive use have been.

The Alaskan Indians also make a very wholesome salve, used for cuts, by mixing Sphagnum leaves with tallow and working the two well together. Dr. Walton Haydon, who was in the service of the Hudson Bay Company at Moose Factory

during the years 1878 to 1884, gives the writer the following information: "At Moose Factory on Hudson Bay this moss was used for many purposes. Its commonest use was for infants in place of diapers, the child being wrapped in it and placed in the moss bag in which it was carried. I never saw a case of chaffing unless it was from some skin disease. Personally I used it as follows: After collecting the moss it was picked over and sprinkled with a weak solution of carbolic acid. When it was nearly dry it was stored in a jar with a tight cover until it was used. In using it a thin cotton dressing was laid on the wound or sore, then a layer of moss on the cotton and the whole dressing wrapped with a bandage. I found it a very superior way of dressing wounds on account of the absorbent qualities of the moss. It was found best to keep the Sphagnum with a small amount of antiseptic moisture in it, as it broke up and became dusty when thoroughly dried. Although the Indians usually applied the moss directly to a wound, yet sometimes they made a poultice of it. This had the advantage of holding the heat a long time but should not be used too wet."

Early in the present century a school called "Svenska Statens Torfskola" was established at Markaryd, Smoland, Sweden, for the study of peat and peat bogs. Although the main emphasis is placed on peat as a fuel in this institution, yet some consideration is also given to the possibility of Sphagnum as a surgical dressing.

Like many other great discoveries and inventions, the use of Sphagnum as a surgical dressing was discovered by accident. "In the early eighties of last century a workman at one of the outlying peat moors in north Germany accidentally sustained a severe lacerated wound of the forearm. In the absence of anything better to apply to the wound, his fellow-workman wrapped it up with fragments of peat which were lying near, and after an interval of ten days he arrived at the surgical clinic at Kiel with the original dressing undisturbed. It was feared that the wound when exposed to view would be found in a very unsatisfactory state, but on the contrary when the peat dressing was removed the wound was found to have healed in a most satisfactory manner. The unexpected result obtained with a dressing material which at first sight seemed so unpromising led to a very careful inquiry into its nature and properties. An investigation was made from the physical, chemical and bacteriological points of view of the growing plant on the surface of the moor downward through the various stages of decay to the brown amorphous

phous depths below."³ The practical outcome of this inquiry was that the value of Sphagnum as a surgical dressing was found to be due to its marvelous power of absorbing fluids. It was found that the growing plants collected and dried had this power at the maximum, but the light brown layers of semi-decayed moss which lie above the peat proper retain great absorptive powers also. It is probable that it was from this partly decayed material that the temporary dressing just mentioned was taken. This account was given by Neuber,⁴ a German surgeon, in 1882. It was followed by a number of other articles on the same subject by other writers.

Sphagnum was first employed in a large way during the Russo-Japanese war, in which the Japanese used it quite extensively as a first-aid dressing. Many of the wounds thus dressed were not inspected again until the patient reached Japan, which often took ten days, but almost invariably the wound was in good condition; much better it is said than when cotton was used.

Although the value of Sphagnum as a surgical dressing was known perhaps to the majority of the surgeons of Germany, it was not used to any great extent until the present war began.

What the British Have Done.

Shortly after the war broke out in 1914 Dr. C. W. Cathcart, an Edinburgh surgeon and a lieutenant-colonel in the medical corps of the British Army, began experimenting with it in one of the Scottish war hospitals. The first published account of these experiments, together with the general account of the moss as a surgical dressing, appeared in *The Scotsman* of November, 1914.⁵ Dr. Cathcart then formed an organization for collecting and preparing the peat moss for surgical pads in Edinburgh. This was the first organization formed for this purpose among the allied nations. In September, 1915, a second one was formed in the South of Ireland by the Marchioness of Waterford. The work thus begun was so promising that new organizations sprang up all over Scotland and Ireland under the directions of the War Dressings

³ Charles W. Cathcart. Cheap absorbent dressing for the wounded. *British Medical Journal*, July 24, 1915, pp. 137-139.

⁴ *Erfahrungen über Iodoform und Torf-Verbande.* Arch. f. Klin. Chir., Vol. 27, p. 757. 1882.

⁵ Charles W. Cathcart & I. Bayley Balfour. Bog Moss for Surgical Dressings. *The Scotsman*. Nov. 17, 1914.

Supply Organization in Edinburgh, and the Irish War Hospital Supply Depot in Dublin. During this experimental stage there was considerable opposition to this kind of surgical pad, but as time went on and the method of making the dressings was improved, this opposition disappeared. Thus in February, 1916, the British War Office accepted them as "Official" Dressings, placing all the volunteer organizations under a Director-General of the Voluntary Organizations, with Sir Edward Ward at its head. With this recognition and organization the work rapidly increased. "The total British output of dressings from Sphagnum, amounting to barely 250 per month in September, 1915, had reached 150,000 per month a year later, and exceeded 200,000 from officially organized bodies alone by the last of the year.⁶ Since then the output of Sphagnum dressing has gradually increased so that at the present time (1918) the British are making 1,000,000 pads a month. It has been estimated that if absorbent cotton were used exclusively in the hospitals the cost would be not less than \$200,000 per annum for Great Britain alone, while the cost of the moss is practically negligible.

The Sphagnum work in America has been more recent than that in Europe. During the summer of 1916 Dr. J. B. Porter of McGill University became interested in peat moss for surgical dressings. Samples were collected in eastern Canada, especially Nova Scotia, and sent to Britain for approval. It was late in the season before definite reports could be obtained from these samples, so comparatively little was done before the bogs were frozen.

In the spring and summer of 1917 this work was continued by the Canadian Red Cross under the direction of Dr. Porter. Although no very large number of dressings was made, yet the organization was extended and perfected, and the bogs containing the desirable moss located so that if the demand became more urgent the production of this kind of dressing could be rapidly pushed. The demand came in January, 1918, in the form of an order from the British War Office for 20,000,000 Sphagnum surgical dressings. The Canadian Red Cross is thus planning extensive work along this line during 1918.

How the Work Began in the United States.

After the United States entered the war more interest was taken in this work by Americans. During the summer of 1917 the late Harry James Smith, acting under the direc-

⁶ John B. Porter. Sphagnum surgical dressings. Internat. Jour. Surg., May, 1917.

tion of the National Surgical Dressings Committee of New York, visited eastern Canada and worked with Dr. Porter. Through Mr. Smith's generosity Sphagnum was gathered and shipped from Nova Scotia to New York City and there made into surgical dressings similar to those made by the Canadians. During the fall this committee made up about 2,000 pads and sent them directly to France. However, when the American Red Cross undertook this work early in January, 1918, the National Surgical Dressings Committee discontinued it, and Mr. Smith entered the National Bureau of Development, with Sphagnum dressings as his special work.

While this was going on in the East, similar work was started in the West. Early in July, 1917, a request came from the French Relief to the President of the University of Washington, at Seattle, to ascertain if suitable moss for surgical dressings grew in this region. This communication was handed to the writer, who immediately collected samples from various bogs in the vicinity of Seattle and sent them to the French Relief Committee at Chicago, where Mrs. J. Gordon Wilson, who had just returned from France and had seen the value of these pads at first hand, was attempting to form an organization to make these dressings. The samples presented were declared suitable for surgical work, but the supply of moss was too far away from the people of Chicago for them to handle the work. The writer obtained working directions from this committee, and also from Dr. Porter of Montreal, so that by the time the University opened in October sufficient information had been accumulated from various sources to warrant going ahead and making some of the dressings. The directions followed were those obtained from Canada, as the American Red Cross had, as yet, no definite instructions for this phase of Red Cross work.

As soon as the University opened, the Faculty Wives' Club undertook to make the pads for the French Relief, and any success that has been attained is largely due to their co-operation. The faculty men collected the moss. The students and interested persons in the neighborhood of the University sorted it. During the first week 2,264 pads were made and shipped direct to France through the French Relief. At the end of that time it was thought best that this club be identified with the American Red Cross, consequently a local auxiliary of the Seattle Chapter was formed. Since then and up to March 1, 1918, this auxiliary has made over 10,000 surgical dressings and 460 ambulance pillows. These have been accepted by the Red Cross and shipped through the

regular channels. During this time four other auxiliaries began making these pads under the writer's direction, one at Aberdeen, one at Olympia, one at Everett and the Faculty Women's Club of the University of Washington. Up to March the first, these auxiliaries made about 2,000 pads.

Realizing the possibilities of this Red Cross work, the War Emergency Committee of the University of Washington appointed a sub-committee on Sphagnum with the writer as chairman. It was felt desirable and even necessary to know where the best moss was located. To this end the sub-committee sent a circular letter to all the botany teachers in the high schools of western Washington, the principals of public schools, to the forest rangers and to the other persons who might be able to give information as to the location of peat bogs and the approximate amount of moss in them. In this survey large numbers of bogs were located, estimated at



Fig. 10.

A group of moss pickers with the result of their labors.

25,000 acres. The first estimate of the quantity of moss in individual bogs was frequently found to be greatly exaggerated. In many of these the character of the moss rendered it absolutely useless for surgical work. The next step then

was to locate bogs containing desirable moss, and, when possible, to instruct some local person how to distinguish and collect this material. To accomplish this small samples from each bog that was reported were called for. In cases in which it seemed necessary the writer visited these bogs and gave instructions as to collecting and shipping. In most instances the instructions could be given by samples and letter. In this search for Sphagnum the Mountaineers of Seattle, Tacoma and Everett rendered a splendid service.

It was soon ascertained that although there were large quantities of Sphagnum in the vicinity of Seattle, there was very little that could be considered high grade and suitable for surgical dressings. The first bog containing the better species of moss (*Sphagnum palustre*) was located in the vicinity of Buckley. There the public school and the local Red Cross auxiliary organized to gather and ship it to the University. Later large quantities of this better grade were found along the west side of Hood Canal from Port Ludlow to Potlatch, mostly *Sphagnum palustre*. Very desirable moss has also been located around Shelton, Matlock and other places in Mason County. In Snohomish County, although large numbers of bogs occur, only isolated ones containing good material have thus far been located, near Stanwood, Tulalip and Silver Lake. Several bogs containing high grade moss have been reported from Whatcom County, near Sumas, Custer and Ferndale as well as just across the border in British Columbia near Sumas.

The largest and most promising supply of usable moss has been located in Pacific County, especially in the southwestern part of it. The species found in the neighborhood of Ilwaco is largely *Sphagnum imbricatum*, while north of Willapa Bay, where the moss is plentiful, the species is mostly *Sphagnum papillosum*. Farther north along the coast, both north and south of Grays Harbor, desirable Sphagnum in large quantities has been located. These regions have been organized for volunteer collection of moss, and it is expected considerable quantity will be gathered during the summer, the surplus amount being stored for any sudden demands.

Samples have been obtained from several places in Alaska; *Sphagnum palustre* and *Sphagnum papillosum* from the Tongass National Forest near Ketchikan, *Sphagnum imbricatum* from Sitka. Desirable moss has also been received from Anchorage, Skagway, Matanuska, Juneau and other places. It is estimated that there are millions of tons of moss suitable for surgical dressings scattered over the tundras of Alaska.

On March 1, 1918, Sphagnum was officially recognized by the National Red Cross of America and authority given the Northwest Division to make Sphagnum dressings of the new type. The three auxiliaries meeting on the campus of the University of Washington, Seattle, were the first organizations in the United States to undertake this work under the direct authority of the National Red Cross. A preliminary order for 50,000 pads was given the Seattle Chapter, and these are being made at the workrooms on the campus. The instruction in making these new pads was given by the late Harry James Smith, who had come from New York City to investigate the amount of suitable moss available on the Pacific Coast and to introduce the new surgical dressings.

The Faculty of the University of Washington, feeling the importance of this phase of War Emergency work and wishing to assist in completing as rapidly as possible this



Fig. 11.

The late Harry James Smith gathering moss in a bog
on the Pacific coast.

large allotment of pads, voted to require all women of the first and second years in the University to register for two hours a week for moss work during the Spring Quarter. The request for this work came originally from the women themselves through the Dean of Women. They felt that since the men were required to devote eight hours a week to military drill without University credit, the women also should do some definite war work under University supervision. It is confidently expected that the first allotment of Sphagnum surgical pads will be completed at the University before June 15th.

It is interesting to note that the base hospital at Camp Lewis is using Sphagnum dressings instead of absorbent cotton. The moss is collected and sorted by the Tacoma Mountaineers and the nurses at the hospitals make the pads, which have proved highly satisfactory to the surgeons and saved the institution hundreds of dollars.

Collecting and Sorting.

Before beginning to collect Sphagnum one should know exactly what is needed. Samples of the moss should be submitted to headquarters and approved before any collection is undertaken. It is often wise to carry a sample of approved Sphagnum for comparison until one is quite familiar with the work.

It has been found that a great deal of time can be saved by a little care in collecting this moss. The cleaner it is gathered, the more valuable it becomes by saving time in sorting. It is best to take a small handful at a time, shake to get rid of most of the foreign matter, such as twigs, roots, etc. If wet, squeeze out as much water as possible before putting it in the bag, but do not wring it, as that will break and injure the stem. In some instances, especially with *Spragnum imbricatum*, the moss may be removed in large masses with a fork if too much foreign material is not obtained in doing so.

The depth to which usable moss extends varies with the species and environment. In many cases beds of *Sphagnum imbricatum* may be worked to advantage a foot to 18 inches or even farther, depending on whether the plants remain intact or whether a partial decay has begun. In general, whenever the plants begin to break up as a result of the first stages in decay, they must be discarded; but as long as they remain intact, with the stem fairly well crowded with lateral branches, they may be used, the color playing little or no part in determining the suitability. While gathering moss it is

wise to secure all the good material in a given space before proceeding to another, because after a growth has once been disturbed the adjoining plants usually deteriorate and sometimes die.

After it is taken from the bog the moss still contains a large amount of water. If possible it should be taken to some shelter near by and spread out to dry. This may be done on the grass if the weather is fine, otherwise on racks similar to the one shown in Fig. 12. While it is thus drying the coarser and more conspicuous foreign material may be removed. Before it becomes perfectly dry it is repacked loosely in clean

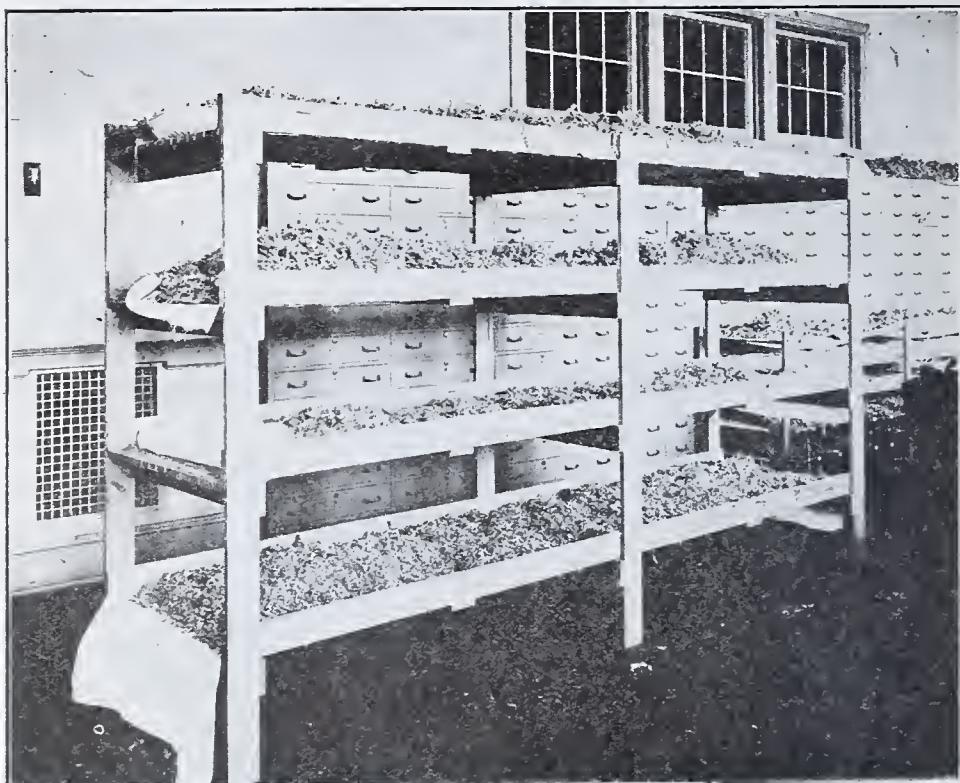


Fig. 12.

A rack for drying moss. The rack is 30 feet long, 27 inches wide and 6 feet high, the shelves 18 inches apart. The bottom of each shelf is chicken wire; the sides 4 inches deep. The wire is covered with unbleached muslin, which may be drawn out when the moss is dry.

gunny sacks and shipped to the workrooms, where the sorting is completed. In an emergency the moss may quickly be made ready for shipment by passing it carefully through a clothes wringer the rollers of which should be as loose as

possible. The moss should be lightly enclosed between strips of burlap as direct contact with the rolls will cause considerable breakage.

The collection of the moss is one of the most important phases in the making of Sphagnum. Much depends upon the condition of the moss when it reaches the sorters if their work is to be most efficient. It has been found that carelessness or thoughtlessness on the part of the collector often decreases the efficiency of the sorter exceedingly. The Canadian Red Cross has emphasized this point in its printed instructions to collectors: "It is impossible to exaggerate the importance of care in collecting the raw moss. In ordinary localities it is impossible at best to avoid collecting considerable proportions of poor moss, and a certain amount of grass and weeds, and it must be remembered that such foreign material not only takes the place of useful moss in the sack, but also that it all has to be laboriously removed by hand when the stuff is sorted. Practical experience has shown that carelessness on the part of the collector often decreases the efficiency and output of the sorter to an enormous extent and not infrequently renders an otherwise useful supply of moss worthless for practical purposes." It should be the aim, therefore, to make a record for the quality, not for the quantity.

The moss should be collected in clean gunny sacks. If the sacks have been used for potatoes or similar material, they should be boiled at least one hour and then dried before using. If gunny sacks are not available packing boxes of convenient size might be used.

The most tedious part of making Sphagnum pads is picking over and sorting the moss. This should be done in some central place and completed before the moss becomes dry. In fact, when making the British pad, it is best not to allow it to get perfectly dry until after it is made into the dressings, because the moss becomes brittle and the small leaves, which are the most valuable part of the plant, break off and are lost. If inadvertently the moss becomes too dry, spread it out in a gentle rain for a short time or sprinkle with water and lay an oilcloth over it.

Besides removing all the foreign material like leaves, twigs, small roots, etc., the moss is usually separated into at least two grades, the first consisting of the softest, most elastic and absorbent plants used for surgical dressings, while the second consists of coarser and less absorbent moss which is suitable for bed pads. The second grade material may also

be used for pillows, which are lighter than the ones made from clippings. It is not wise, however, to gather second grade moss for making bed pads and pillows, since sufficient material for this purpose is ordinarily obtained from picking over the first grade. Fig. 13 is a photograph of a group of women sorting moss in the work-rooms at the University of Washington.

How Sphagnum Dressings Are Made.

Like many other things in connection with this war, the directions for making surgical dressings from Sphagnum have not been static, but progressive. From time to time valuable suggestions as to where the pads could be improved have been received from surgeons at the front who have been actually using them. Acting on these suggestions, the British have gradually increased the efficiency of their moss dressings. More recently the American Red Cross, after some experimentation under the direction of Dr. John A. Hartwell, has adopted a different dressing, which promises to be even more efficient than those authorized by the British War Office. But the last word has not yet been said on Sphagnum for surgical dressings. Both the British and American methods of making them will be briefly discussed.

The present British method of making Sphagnum pads is to put the moss into small bags or pillows of definite size. The material used for this purpose is an English cloth of fairly fine weave, but of the lightest possible weight. Any other material will do equally well, provided it has a close enough weave to prevent the fine particles of moss from coming through. Gauze or cheese cloth is too open for this work. Whatever cloth is used, it must be laundered to get rid of the sizing or stiffness before it is made into pads, otherwise the rapidity with which the liquid passes through the cloth is greatly reduced.

It is very difficult to give exact instructions regarding the weight and thickness of these pads because not only do different species of Sphagnum vary greatly, but there are wide differences between specimens of the individual species themselves from different localities. Under these circumstances no attempt is made to specify exact weights, but merely to give appropriate figures. A rough and ready test which may be used is to hold the dressings up to the light. They should be sufficiently full to cut off nearly, but not quite, all the light. The object is to see that the pad is sufficiently thick to serve its purpose and yet as loose and light as possible with-

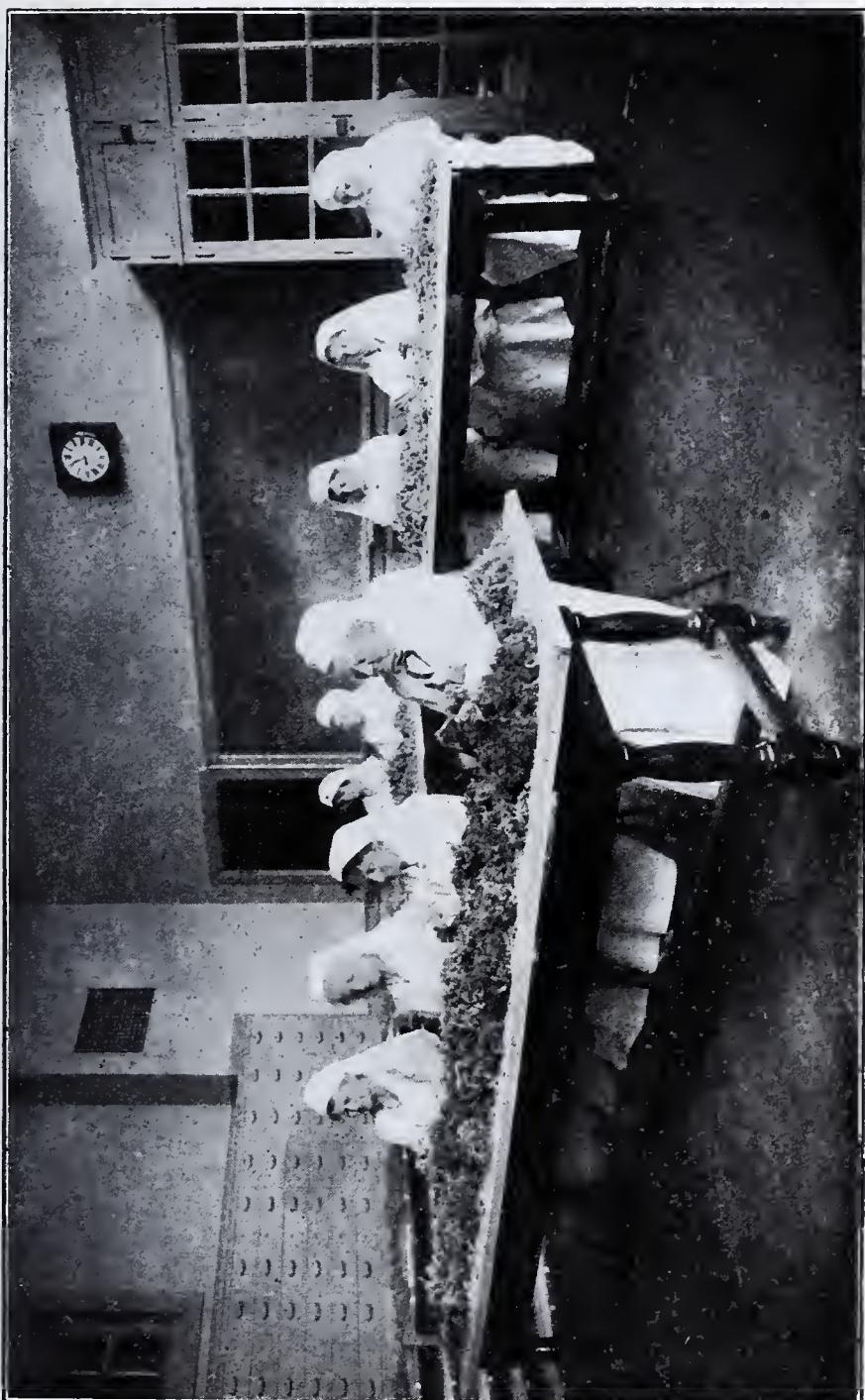


Fig. 13. Sorting moss in the work-rooms at the University of Washington, Seattle.

out sacrificing the absorbent power. This is slightly different from the directions given for oakum pads, into which sufficient material is put to completely shut out all the light. Fortunately, minor difference in thickness and weight are not of great importance, but the accompanying figures may be a guide.

The following table of sizes and weights of Sphagnum dressings are those recommended by the Canadian Red Cross and accepted by the British War Office:

TABLE 1. Approximate weights and sizes of Sphagnum dressings.		
6x 6-inch surgical pads	10	grams or $\frac{1}{2}$ oz. approximately
6x 8-inch surgical pads	14.5	grams or $\frac{3}{4}$ oz. approximately
8x 8-inch surgical pads	18	grams or $\frac{3}{4}$ oz. approximately
8x12-inch surgical pads	28	grams or 1 oz. approximately
12x15-inch surgical pads	53	grams or 2 oz. approximately
18x18-inch surgical pads	106	grams or 4 oz. approximately
18x18 dysentery pads	160-200	grams or $5\frac{1}{2}$ -7 oz.
12x12 pillows or elbow pads.....	80	grams or $2\frac{3}{4}$ oz. approximately
6x19-inch splint pads	25	grams or 1 oz. approximately

It should be remembered that the weights are only approximate. The best qualities of moss are, generally speaking, lighter and fluffier than material of poorer grade. The first-class moss will be usually lighter than the second-class. For the splints, bed pads and pillows either the same long cloth or unbleached muslin may be used.

When Sphagnum dressings are undertaken for the first time, samples are sent to the Red Cross headquarters for approval before any large number is made. These are returned with appropriate criticisms.

To obtain uniformity it has been found quite advantageous to allot to one or two workers the responsibility of cutting out the dressings. After tearing off the selvages and allowing for seams, etc., the cloth is torn lengthwise the required width. For the cross cuts, the thread is usually drawn at twice the required length of each pad. These are doubled and the sides are stitched on a sewing machine; the seams are between one-eighth and one-sixteenth of an inch inside the ravellings. The bags are then turned inside out and filled with the required amount of moss. A group of women sewing these pads is shown in Figure 14. Since the moss is not perfectly dry when it is put into the pads it has been found best to baste the top and leave them until they are dry or nearly so, since frequently they need a little additional moss under these conditions. Fig. 16 shows a rack for drying these pads. They are finally stitched either on the machine or by hand. The bastings and all ravellings are removed. The pads should not be dried by artificial heat, if it is possible



Fig. 14. Sewing surgical pads in the work-room at the University of Washington.

to avoid it. When perfectly dry, they should be tied up in packages of 10, 15 or 20, pressed tightly together, bound with strips of cotton or the selvedge that has previously been torn off, and the size and number of pads marked on the outside of each package. Nearly 15,000 of these pads have been made by the different Red Cross auxiliaries in the State of Washington.

Although the dressings just described are of great value at the front, there are certain criticisms of them offered by American surgeons. In spite of these, however, the British continue to use them at the rate of 1,000,000 a month; and as has already been said, the Canadians have recently received an order for 20,000,000. One of the psychological objections is that they do not look like the pads that American surgeons have been accustomed to using, so there is more or less prejudice against them merely on account of their general appearance. Besides this, when a suppurating wound is dressed with one of these pads, there is nothing to prevent the discharge from soaking through the bandage and soiling the bedding. This undesirable condition is often increased by the manner of applying the pad. As the dressing is drawn over the wound, frequently the center of the pad, which is the part covering the discharge, has the least Sphagnum, most of it being pushed to the two ends, so that the bandage becomes wet long before the moss has finished its work. Looking toward a solution of some of these objections, Dr. John A. Hartwell, Director of Surgical Dressings for the National Red Cross, assisted by the late Harry James Smith, began a series of experiments in New York City during the fall of 1917. These experiments have proved so highly satisfactory that a new type of pad has been introduced. An actual test in the city hospitals of New York has shown that it is a very marked improvement over the official Sphagnum dressings used by the Allies. These experiments are still under way, and any directions that may be given at this time must be construed as merely tentative, since minor changes will probably be made from time to time. Thus far, however, results are quite promising, and it is confidently expected that this new dressing will be a decided contribution toward the efficiency of Sphagnum dressings.

These pads are quite different from the British type just described. They are composed of gauze, a thin sheet of wood pulp paper, non-absorbent cotton and Sphagnum. There is no sewing in connection with them, but simply a process of fold-



Fig. 15. A load of Sphagnum pads on the way to the packing rooms.

ing somewhat similar to the familiar gauze dressings which they resemble in appearance.

The sizes of the dressings will vary from time to time as the War Department may recommend. The following are the sizes being made at the present time. Of these, 8x12 is considered the standard size and the one of which the most are made:

- No. 1. 6x 8-inch Sphagnum absorbent pads; first grade moss.
- No. 2. 8x12-inch Sphagnum absorbent pads; first grade moss.
- No. 3. 11x18-inch Sphagnum absorbent pads; first grade moss.
- No. 4. 11x24-inch Sphagnum absorbent pads; first grade moss.
- No. 5. 16x24-inch Sphagnum absorbent pads; first grade moss.
- No. 6. 11x18-inch Sphagnum paper-backed pads; second grade moss.
- No. 7. 16x24-inch Sphagnum paper-backed pads; second grade moss.

In making one of these dressings, a piece of Scot tissue⁷

of appropriate size is placed on the table and on it a wooden frame corresponding to the particular size to be made. After the frame, which is about three-quarters of an inch deep, is filled evenly with moss it is removed and a thin layer of non-absorbent cotton is put over the Sphagnum. The margins of the tissue are then folded over the cotton and Sphagnum. It is usually convenient to use spring clothes-pins to hold the ends in place. In order to keep the outside covering free from particles of moss it is best to remove this incomplete pad to another table where there is no moss. Here it may be finished by the same worker or by another. A piece of gauze of appropriate size is spread out on the table and the incomplete pad is placed in the center of it, with the non-absorbent cotton up. A thicker layer of cotton is then put over the pad, extending about a quarter of an inch beyond the edges. The gauze is folded over the pad so that the long fold is on the back, that is on the side next the non-absorbent cotton.

The open ends are folded in "muff-wise," first folding the under side up over the tissue-envelope, then folding the upper side to correspond and adjusting the "muff-end" carefully. The pad is patted more or less vigorously to make sure the Sphagnum is evenly distributed throughout and then passed through a clothes-wringer. If, when held up to a strong light, "holes" are detected in the pad too little moss has been used. If the pad is solid and harsh, there is probably too much moss.

⁷ Scot issue is a very thin wood-pulp paper used to envelop the Sphagnum and prevent it from shifting.



Fig. 16. A rack for drying the British type of pad.



Fig. 17. Pads hanging up to drip when testing the absorbency.



Fig. 18.

A diagram showing a portion of a cross-section of a Sphagnum dressing; c, inner non-absorbent cotton; g, gauze; n, outer non-absorbent cotton; t, Scot tissue; s, Sphagnum.

Figure 18 is a portion of a cross-section of one of these dressings, illustrating the relative position of the different parts. The gauze (g) on the outside holds everything in place and exposes a soft absorbent surface to the wound. Immediately above it is the Scot tissue which partially envelopes the Sphagnum and the thin layer of cotton. The Sphagnum (s) is the absorbing agent, the thin layer of cotton (c) just above it tends to keep the moss from shifting, while on the back of the pad the packing of non-absorbent cotton (n) prevents the discharge from soaking through the bandages.

The paper-back pads, which are of two sizes, are bed pads used largely for dysentery patients. They are made in a manner similar to the ones just described, except that a second grade of moss is used instead of the first grade and that five thicknesses of newspaper, cut to the specified dimensions of the pad, are sewed to the back of it with large "over-and-over" stitches. In the larger size, the pads should be caught down once to the newspaper at the middle of each side.

Absorbency of Sphagnum.

In order to obtain some definite information regarding the absorbency of the various species of Sphagnum found on the Pacific Coast, a series of tests have been undertaken. It has been observed that the same species of Sphagnum frequently varies considerably when found under different environmental and climatic conditions. Wherever possible tests were made to determine what effect these different conditions had on the absorbency of the plants. Sphagnum palustre in particular is susceptible to variation due to local influence. Species found in somewhat shallow places in the bog, or in bogs that have a limited supply of water, especially if they are partially drained, are so different in general appearance from those found where conditions are more favorable that one would hardly suspect that they were identical.

The method adopted for testing the absorbency is practically the same as that used by Porter.⁶ About 30 special pads 6 inches square were made very carefully of long cloth, so that they all weighed exactly the same, 5 grams. When a sample of moss was to be tested, at least three and sometimes five of these bags were used. Into each 5 grams of air-dried Sphagnum was put. The bags were then placed in a tray containing distilled water, about one centimeter deep, and the time it took the moss to become saturated was observed. More distilled water was added to the tray from time to time as it was needed. When the moss was saturated

the bags were hung up to drip. This was done either by attaching them by the corner to a string stretched across the room (Fig. 17), or more often the pads were pinned to the edge of a table. They were allowed to remain in this position until they ceased dripping, after which they were weighed, and the contents immediately emptied and the wet bag weighed. The difference in the weight of the saturated bag of moss and the saturated bag alone gave the weight of saturated moss. The absorbency is obtained by dividing this number by five. A few of the tests are given in Table 2.

TABLE 2. Showing the absorbency of Sphagnum.

Kinds of Moss	Where Obtained	Wt. of Dry Moss	Wt. of Sat. Moss	Absorbency
Sphagnum palustre	Nahcotta, Wash.....	5	102	20.4
Sphagnum paulstre	Nahcotta, Wash.....	5	102	20.6
Sphagnum paulstre	Buckley, Wash.....	5	93	18.6
Sphagnum paulstre	Tulalip, Wash.	5	77.6	15.5
Sphagnum paulstre	Tulalip, Wash.	5	79.8	15.9
Sphagnum paulstre	Stanwood, Wash.	5	88	17.6
Sphagnum palustre	Stanwood, Wash.	5	84.5	16.9
Sphagnum imbricatum	Ilwaco, Wash.	5	91	18.2
Sphagnum imbricatum	Ilwaco, Wash.	5	90	18
Sphagnum imbricatum	Sitka, Alaska.....	5	84	16.8
Sphagnum imbricatum	Sitka, Alaska.....	5	83.7	16.7
Sphagnum papillosum	Ketchikan, Alaska....	5	72	14.4
Sphagnum papillosum	North Cove, Wash...	5	77.6	15.5
Sphagnum papillosum	North Cove, Wash...	5	79.8	15.9
Sphagnum papillosum	North Cove, Wash...	5	71	14.2
Sphagnum fuscum	Grayland, Wash.	5	59.8	11.96
Sphagnum fuscum	Grayland, Wash.	5	59	11.8
Sphagnum fuscum	Belmore, Wash.	5	58.5	11.7
Sphagnum fuscum	Belmore, Wash.	5	58	11.6
Sphagnum fuscum	Grayland, Wash.	5	54	10.8
Sphagnum fuscum	Grayland, Wash.	5	67	13.4
Sphagnum fuscum	Grayland, Wash.	5	71.5	14.3
Sphagnum fuscum	Grayland, Wash.	5	70	14
Sphagnum recurvum tenuer.....	Covington, Wash.	5	43.5	8.7
Sphagnum recurvum tenuer.....	Covington, Wash.	5	42.5	8.5
Sphagnum recurvum tenuer.....	Covington, Wash.	5	36.5	7.3
Sphagnum recurvum tenuer.....	Covington, Wash.	5	39	7.8
Sphagnum capillaceum tenellum	Belmore, Wash.	5	56	11.2
Sphagnum capillaceum tenellum	Belmore, Wash.	5	61.4	12.3

Species of Sphagnum Suitable for Dressings.⁸

There are about 50 species of Sphagnum in America. Of these only about four can be depended upon for surgical dressings. Along the coastal regions of the Pacific northwest 23 species are found. Among these are the four suitable for surgical dressings; namely, *Sphagnum palustre*, *S. papillosum*, *S. imbricatum* and *S. magellanicum*. All of these are high in absorbency (table 2), varying from 14 to 20. Thus it will be seen that there are a large number of species of Sphagnum which are of little or no use for surgical dressings, and great care should be exercised to insure that the most suitable species are obtained. The qualities of suitable Sphagnum are softness, flexibility, elasticity and an absorbency which is not less than 10.

The above mentioned species most frequently fulfill these conditions, although occasionally even these have to be discarded on account of not measuring up to some of these requirements, due largely to the influence of some local environment. This is particularly true of *Sphagnum palustre*, in which under certain conditions a more or less wiry stem is developed which sometimes becomes so pronounced as to render it useless. On the other hand not infrequently we find that other species which are usually avoided for surgical work, when grown under favorable conditions, prove quite satisfactory, fulfilling practically all the requirements. Thus, the distinction between suitable and unsuitable material for surgical pads is not entirely a difference of species, but often a difference in the condition of growth.

The plants belonging to these four species are low, compact and robust. They are usually somewhat green but occasionally tinged with brown, reddish-brown or pink. They have comparatively large leafy stems which give the plants a soft, fluffy appearance comparable, in some cases, to the softest plumage.

They vary considerably in their general appearance, however, under different conditions of growth so that it is impossible to distinguish them at all times by their external appearance. The method of identifying these species is largely by the character of the internal structure of the leaves, which is not readily subject to change by external conditions.

They all have spiral thickenings in the cortical cells of the stem and branches. If a cross-section of a leaf is made,

⁸The writer is indebted to Prof. T. C. Frye for the identification of the species of Sphagnum.

such as is seen in Figure 6, it will be found that in *Sphagnum megellanicum* the green cells are elliptical or oval, and usually not exposed on either surface of the leaf, or if at all only slightly on the inner surface. The walls of the hyaline cells are smooth where they come in contact with the green cells. The stem leaves are wide at the apex. This species, which is probably the least valuable of the four, is found abundantly along the straits of Magellan, hence the name. It occurs very sparingly in Washington.

In the case of *Sphagnum papillosum* the green cells appear lenticular to truncately elliptic, usually about the same amount of exposure on both sides of the leaf. The walls of the large hyaline cells are smooth to densely papillose where they come in contact with the walls of the green cells. The stem leaves are narrow at the apex. Extensive bogs containing *Sphagnum papillosum* are located north of Willapa Bay in Pacific County, and also along the coast in Grays Harbor County.

The green cells of *Sphagnum palustre* in cross-section (Fig. 6, g) appear as isosceles triangles which are narrower than an equilateral triangle and exposed only on the inner surface of the leaf. The walls of the large hyaline cells are smooth where applied to the green cells. The stem leaves are wide at the apex. This species is the most abundant in Washington. It is found well distributed over the Olympic peninsula, along Hood Canal, in Mason, Grays Harbor and Pacific Counties. It is also found in the vicinity of Sumas, Custer, Ferndale, Stanwood and Buckley.

In *Sphagnum imbricatum* (Fig. 1) a cross-section of a leaf shows the green cells as equilateral triangles which come to the surface of the leaf only on its inner side. The walls of the hyaline cells are strongly papillose where they come in contact with the green cells. The stem leaves are rather narrow at the apex. *Sphagnum imbricatum*, which is perhaps the most desirable species of the four, usually occurs in dense hummocks, often valuable moss extending a foot below the surface. The main source of supply of this species is in the vicinity of Ilwaco and certain regions of Alaska.

Among the species of *Sphagnum* that are less desirable are a few that might be mentioned. There is a small, slender, delicate species, *Sphagnum fuscom* (Fig. 4), which is usually compactly matted together in small hummocks. The plants are normally brown, but sometimes with only a trace of this color. Another species, *Sphagnum capillaceum*, resembles it in texture and general appearance except that it is red

or has a reddish tinge rather than a brown. Both of these species, but particularly the former, are abundantly distributed throughout Washington and northward to Alaska. The most serious drawback to these species is a tendency to break up or crumble when dry. Even with very careful handling the leaves and small lateral branches break off and are lost. This is a somewhat serious objection, because it lessens the efficiency of the moss, since it is these leaves that do the major part of the absorption. Further, their absorbency is comparatively low, ranging from 10 to 13. These two features prevent them from being used alone for surgical dressings. However, they are soft, flexible, and fairly elastic, so that when mixed with about two-thirds of the better grade of moss they make quite satisfactory pads. Another species found commonly in the vicinity of Seattle is *Sphagnum recurvum* (Fig. 3). These plants are quite robust and have fairly long stems which are usually brittle and green in color. Their absorbency is low, ranging from 7 to 9. Even with the most careful selection of material it seldom runs over 10. This is partly due to the fact that the leaves are not only small and sparingly developed, but the cortical cells of the stem do not have pores, as in *Sphagnum palustre*. Moreover, this species when dry becomes very brittle and also produces a fine dust similar to that of *Sphagnum fuscum*.

Sterilization.

The sterilization of all *Sphagnum* pads is done in France just prior to their use. This is accomplished by means of an autoclave in which the pads are placed and subjected to steam pressure of 15 to 20 pounds for 20 minutes. This high heat and pressure tend to make the moss brittle and to lessen its absorbency, but not to such an extent that it is entirely destroyed or even seriously impaired.

Early in his experiments Dr. Cathcart of Edinburgh discovered this effect on the moss when heat was applied. In an effort to overcome this difficulty he tried a number of experiments, using corrosive sublimate to sterilize. The strength adopted for moss was that commonly used for absorbent cotton, namely, one-quarter of one per cent. In order to determine the strength of the solution in which to soak the moss he first found what would be a convenient quantity of water to be left in the moss after the surplus had been wrung out of the pads. This depended, among other things, on the efficiency of the apparatus for squeezing out the water. The exact quantity left in the moss does not matter as long as the

method adopted in making the calculations is not varied. In the apparatus used by Cathcart, which was a common clothes-wringer, it was convenient to leave 20 oz. of the fluid for every pound of moss. That is, 16 oz. of dry moss weighed 36 oz. after having been soaked and wrung. The pads being thus treated were hung up to dry, after which they were ready for use.

In the experiments carried on by the writer, autoclaving had little or no effect on the rate of absorption, and the total reduction was so slight that it was not a serious objection. Moreover, in actual practice it is probable that seldom, if ever, does a Sphagnum pad reach the limit of its absorptive power, so that if only a small decrease in the maximum occurs its usefulness is not seriously reduced. This is particularly true with the high grade moss such as is recommended for surgical work.

In Conclusion.

As already mentioned, the last word has not been said regarding Sphagnum for surgical work. Experiments are constantly going on, looking toward improvement in these dressings.

It should also be pointed out in conclusion that although Sphagnum for surgical dressings has been largely the result of the present war, a makeshift for a necessity that has arisen, yet there is every reason for believing that it is not going to be discarded when the war ends. The inexpensiveness of the moss, its high absorbency, its abundance in certain parts of the country and its undoubted superiority over gauze and absorbent cotton for some purposes, clearly indicate that it is too important as a hospital equipment to let die with the war. When the war is over it will probably take its place as a regular commercial product called for by the modern hospital.

This opportunity is taken for paying the highest tribute to the memory of the late Harry James Smith of New York City, who was killed in an automobile accident near Murrayville, B. C., March 16, 1918, where he had gone in search of Sphagnum. Mr. Smith was "a full-time volunteer" connected with the National Bureau of Development of the American Red Cross with Sphagnum Dressings as his special work. He arrived in Seattle two weeks previous to his death to investigate the Sphagnum situation and to ascertain if sufficient desirable moss was available in this Division to warrant the ex-

pansion of the work. Besides this he gave instructions in the method of making the surgical pad referred to above. His untimely death has been a serious blow to the cause of moss dressings and a great loss to his country, for which many more years of patriotic service might well have been expected.

DANISH SYNDICATE TO MAKE PEAT WOOL.

A Danish syndicate has procured the right of using in Denmark a patented method, with machines belonging thereto, for the winding and treatment of peat wool.

The method that will be used in Denmark for the production of peat wool differs on various points from the one which the Swedish factory uses, the aim being to make the fiber as crimped and curly or, in other words, as "woolly" as possible. This permits the use of the peat wool without the addition of wool or cotton; or, where such admixture is necessary, only a small percentage is needed, which of course makes this way of preparation more economical than the other.

One of the largest textile factories of Sweden is negotiating with the Danish company which has bought the right of utilization here, and it is therefore quite possible that before long we will have a Danish industry founded on peat wool. Furthermore, it is not only in this industry that the wool can be utilized, but, for example, also for the preparation of cardboard for boxes, etc. For this is used a mixture of 70 per cent fiber and 30 per cent wood pulp.

The first step in the preparation of peat fiber will be taken at the spot where the peat is cut. From the marshes the fiber will then go to the mills, to be spun into thread and woven into cloth of different kinds, and lastly will end at the tailor's whose small stock of fabric will then be replenished. Such is the outlook for the future, and with the samples that have been seen of "peat cloth" this will soon be realized.

(Consular Report.)

The Peat Deposits in Minnesota^{*}

E. K. Soper.[†]

INTRODUCTION.

It has been known for some time that Minnesota contains large deposits of peat, but, up to the present, no detailed information has been available regarding the quantity and quality of Minnesota peat, and the uses to which it is best adapted. An investigation was undertaken to determine these facts and some of the results are outlined below. The work was done by the writer for the Minnesota Geological Survey and Mr. Percy G. Cowin assisted in the field.

CONDITIONS OF PEAT FORMATION IN MINNESOTA.

Occurrence.

Peat deposits form only in depressions filled with water, such as lakes and ponds, or on low, flat, or very gently sloping surfaces, where the water table is constantly at the surface, therefore always wet. Plate XXXI. shows various types of Minnesota peat bogs.

Climatic Influences.

The most important climatic influences in peat formation are (1) regular and abundant rainfall, and (2) high humidity of the air. A third should be mentioned, namely, a cold or temperate climate, but this is not absolutely necessary, for peat deposits are known in warm climates such as that of Florida.

The conditions essential to the formation of extensive peat deposits are prevalent in eastern North America north of 40° N. Latitude and most of the peat in the United States lies north of 40° N. Latitude and east of the Dakotas. The largest and deepest deposits in North America occur within this area, along the Canadian boundary, on both sides of the line.

The influence of climate upon the origin and accumulation of peat is well shown in Minnesota; the largest and deepest peat bogs are all in the northern portion of the state, where the mean annual temperature is 8 to 10 degrees colder than in the southern counties.

The least rainfall is in the northwest corner of the state,

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†Dean of School of Mines, Corvallis, Ore.

where there is no peat whatever. From the North Dakota boundary, the rainfall increases steadily to the eastward as far as the Lake Superior region, a vicinity in which are found some of the largest peat bogs in America. There are some localities in northern Minnesota, chiefly north of Lake Superior, where, in spite of the cold climate and abundant precipitation, there is little or no peat. This is due to the topography of these regions, which is so hilly and rocky that no marshes or bogs could form.

Topographic Influences.

Just as the climate of a region controls in part the quantity of peat which may form, so the topography controls the distribution of the deposits. Given all conditions favorable except topography, no peat would form, since its formation requires the existence of basins, depressions, or flat, undrained areas, in which the plant remains can accumulate and be protected from decay and decomposition.

The principal topographic divisions in Minnesota are: (1) a complex system of morainic belts and partially filled kettle holes; (2) gently undulating belts of modified glacial drift, such as outwash plains, clayey till plains, etc.; (3) several large lake beds, the most important of which are those of ancient Lake Agassiz in the northwestern part of the state, the large lake which once covered a part of St. Louis County, and the delta deposits of the glacial Lake Superior in the northwestern portion of the state. In some localities, especially in northeastern Minnesota, rock hills rise above the glacial drift. The largest and most numerous moraines occur in northern and central Minnesota, and many peat bogs, some of which are very deep, occupy the depressions and basins in these morainic belts.

The altitudes of Minnesota range from 602 feet, the level of Lake Superior, to 2,230 feet, the highest point in Cook County in the northeast corner of the state. This gives a maximum relief of 1,628 feet. Most of the state, however, has a gently undulating surface of slight relief, with extensive flat areas which represent ancient glacial outwash plains, or old lake beds, many of which are covered with peat deposits.

Effect of Glacial Influence upon Peat Formation.

Nearly all the peat deposits in the northern United States (Minnesota, Wisconsin and Michigan), as well as those of eastern Canada, owe their origin directly or indirectly to the influence of glaciation. Before extensive deposits of peat may be formed, the three essential factors in peat formation, i. e.,

climate, topography and vegetation, must all be favorable. In northern Minnesota the topography is the direct result of glaciation, while the climate and vegetation have been indirectly controlled by the same glacial influences.

At least 95 per cent of the peat in Minnesota lies north of Minneapolis and St. Paul, and hence it is necessary to consider only the glacial drift of the northern part of the state in studying the influence of glacial drift upon peat formation. All the peat in Minnesota rests upon glacial drift, or modified drift. In northern Minnesota there are only two important drift sheets exposed at the surface and in contact with the peat. These are: (1) The **Young Red Drift**, in northeastern Minnesota, and (2) the **Young Gray Drift**,² in the northwestern and central parts. Both of these drift formations probably belong to the youngest, of Wisconsin Stage of Pleistocene Glaciation. The largest peat bogs overlie the water-sorted gray drift which constitutes the bed of ancient Lake Agassiz, which in turn rests upon calareous gray drift. A careful study of the peat bogs of northern Minnesota, with reference to the nature of the drift upon which they rest, shows that the peat deposits are not confined to any single drift formation, but that they occur over areas of red as well as of gray drift. The largest deposits, however, exist within the area of gray drift, but this is due to topographic conditions rather than to any influence exerted by the composition of the drift.

Relation of Marl Beds to Peat Formation.

Many lakes in central and northern Minnesota contain valuable deposits of marl, the origin of which is clearly due to precipitation of lime carbonate from solution in the lake waters through the agency of the plant, **Chara**³ (stonewort). When the **Chara** are displaced by the invasion of other water-loving plants, the accumulation of marl in the lake may be followed by the accumulation of peat. Under such conditions, which were frequently observed in Minnesota, the lake may ultimately become completely filled with marl and peat. The marl always lies on the bottom and is not sharply separated from the overlying peat. The peat may continue to form after the lake is filled by the accumulation of successive layers of dead plant remains on the surface of the bog. The presence, therefore, of a considerable number of peat bogs in Minnesota, underlain by beds of pure marl, is readily explained when the history of these marl deposits is known.

²Leverett, Frank, "Surface Formations and Agricultural Conditions of Northwest Minnesota," Minn. Geol. Survey Bull. 12, p. 32.

³For an excellent account of the origin of marl see Davis, C. A., Michigan Geo. Survey, Vol. 8, 1900-1902.

Depth of Peat Accumulation.

The depth of peat accumulation depends chiefly upon the form of surface at the site of accumulation; the climate; amount, and character of vegetation. The form of land surface is the principal factor controlling the depth.⁴ Peat deposits formed in lakes or basins are usually deeper than those formed on flat surfaces or in slight depressions. It should be understood, however, that the depth of a given basin does not necessarily determine the thickness of peat which may accumulate there. Under certain conditions, peat may continue to accumulate after the basin has become filled, by the addition of successive layers of dead vegetation to the surface of the bog, thus building up the deposit above the former lake level, or above the original rim of the basin. Numerous examples of such deposits were observed in the northern part of the state.

The peat deposits of Minnesota vary in thickness from a few inches up to 63 feet. The deposits in the southern portion of the state are generally much shallower than those in the north, because there the topography, climate, and vegetation are all unfavorable to thick accumulations. The maximum thickness noted in the southern bogs is 18 feet. The majority of the deposits of that region, however, are less than 5 feet thick. In the north many of the bogs are 20 to 25 feet thick in the center, especially those of the filled-lake type.

The average depth of peat in the great built-up deposits occupying portions of the bed of Lake Agassiz in north-central Minnesota is 7 to 9 feet but increases to 18 or 20 feet in many places. These deeper areas evidently represent depressions and hollows below the general surface of the old lake bed, which probably remained as temporary ponds and lakes after the main body of water had disappeared from this region.

Rate of Peat Formation.

The rate of peat formation varies with the amount of vegetation, moisture and other conditions. Dana⁵ gives as a maximum rate of peat accumulation 1 foot in five or ten years. This maximum has not been reached in Minnesota, in the writer's opinion, and there is evidence that the rate of growth has been very much slower.

Since all of the lakes of the state are of glacial origin, it is not unreasonable to assume that they are approximately

⁴See Shaler, N. S., "General Account of the Fresh Water Morasses of the United States," U. S. Geo. Survey, 10th Annual Report, p. 262.

⁵Dana, James D., "Manual of Geology," 4th ed., p. 154.

of the same age, and that peat accumulation began in many of these lakes at about the same time. At those places where the lakes became filled with peat to the original water level, after which peat accumulation stopped, it is impossible to get any significant evidence as to the rate of accumulation, since there is no means of determining how long a time has elapsed since peat formation stopped. In other lakes, however, peat formation did not stop when the lake became filled to the rim of the basin, but peat continued to form, building up the surface of the bog many feet above the original lake level by the addition of successive layers of vegetation. In deposits of this type, where peat is in active process of formation today, the evidence obtained from the study of numerous sections of the deposits indicates that peat accumulation has been continuous from the time it first began, which probably was not long after the origin of the lake. If this assumption be even approximately correct, we have a rough means of estimating the rate of peat accumulation. Reckoning the time which has elapsed since the close of the Pleistocene Glacial Period at 10,000 to 30,000 years, and taking 18 feet as the average thickness of some of the largest filled-lake bogs, and assuming the accumulation to have been uninterrupted by fires or drought, we get a growth of .022 to .0072 inches per year as the average annual rate of peat accumulation in northern Minnesota, in bogs of the filled-lake type.

In the built-up deposits, formed on flat, wet land surfaces by successive layers of plant remains, the rate of peat accumulation is probably much more rapid than in filled-lake deposits.

Classification of Minnesota Peat Deposits.

The most logical classification of peat deposits is probably that based upon the type of land surface upon which the peat is formed. Upon such a basis the following types of deposit may be recognized:

1. Deposits which represent filled lakes or ponds (Fig. A, Pl. XXXII.).
2. Deposits which represent accumulations built up on moist depressions, or flat, undrained areas (Fig. B, Pl. XXXII.).
3. Deposits which represent combinations of types 1 and 2, and which consist of lake, or pond peat, in the lower portion, and swamp, or sphagnum peat, above. These

often resemble type 1 or 2 in appearance, and their true nature may only be ascertained by soundings.

4. Deposits which occur on flats and lowlands along river valleys.

ASSOCIATIONS OF PEAT-FORMING PLANTS.

Peat deposits may be divided into two main groups according to the type of surface upon which the peat accumulated. These are: (1) peat deposits formed in basins filled with water, and (2) peat deposits formed on flat, or gently sloping, undrained, land surfaces. The plant associations active in forming these two types of deposit are entirely different, especially in the earlier stages of development of the bogs. In order to clearly trace the origin of peat and the various developmental stages in the history of the peat deposits, the plant associations which are characteristic of these two types of bog should be considered.

Plant Deposits in Lakes and Ponds.

Peat bogs in coniferous forest regions go through the following developmental stages, if not arrested through the influence of some external agency.⁶

1. Stonewort—waterweed stage. (Chara-Philotria Associes.)
2. Pondweed—waterlily stage. (Potamogeton-Nymphaea Associes.)
3. Rush—wild rice stage. (Scirpus-Zizania Associes.)
4. Bog meadow stage. (Carex Associes.)
5. Sphagnum—bog heath stage. (Andromeda-Ledum Associes.)
6. Tamarack—spruce stage. (Larix-Picea Associes.)

In the deciduous forest regions the peat bogs go through essentially the same stages until the lake is filled with peat, when the swamp plants are replaced by those of the climax vegetation, and the accumulation of peat is stopped.

In the prairie regions the swamp vegetation is never replaced by trees. Bog-heaths, tamarack, and spruce are never found. The swamp or bog-meadow stage is the highest stage attained by peat bogs of the filled-lake type in the prairie regions. The developmental stages preceding the swamp stage are the same as for the forested regions. When a prairie swamp fills up and becomes too dry for peat accumulations, the swamp vegetation, consisting chiefly of sedges, reed-grasses, etc., is replaced by the typical prairie grasses, such as blue-stem, Indian grass, and porcupine grass.

⁶Bergman, H. F., Department of Botany, University of Minnesota. Unpublished manuscript.

Peat Deposits on Flat, or Gently Sloping, Wet Surfaces.

A swamp represents an arrest in the natural development of the vegetation of a region. In the case of swamps derived from filled lakes, just described, they are arrested **primary successions**.⁷ If the arrest in the vegetational development is caused by some outside influence, such as glaciation, flooding, forest fires, etc., a **secondary succession** may be initiated. Thus, any cause which destroys the existing vegetation of a region may start a secondary succession, and the secondary succession may begin at any point between the first stage and the climax vegetation. Peat bogs which have been built up on flat, wet, or flooded surfaces are secondary successions.

In Minnesota and throughout most of the Lake Superior region, where the largest and deepest bogs in the United States occur, there are many extensive swamps of this type. The chief agency which has initiated these secondary successions has been **glaciation**. The glaciation of this region completely destroyed all the existing vegetation. Upon the melting and recession of the ice, the drainage of the recently denuded surface was blocked, and large areas of flat or depressed land lying south of the retreating ice sheet were flooded, and temporary glacial lakes formed. Other large areas, while not covered with water and converted into lakes, were kept constantly wet and marshy. Upon such surfaces as these the built-up peat bogs of the northern states have been formed.

The peat in many of these bogs consists chiefly of sedge and grass remains, showing that the deposit remained for a long period in the bog-meadow stage. In other bogs of this type the peat consists almost entirely of the remains of sphagnum, or peat moss, showing that this plant obtained a strong foothold among the first plants to appear after the recession of the ice, and that the development of the resulting bog was more or less permanently arrested in this stage.

Under ordinary conditions the swamps originating by secondary succession (built-up bogs) may pass through the same stages of development as those originating by primary succession (filled lakes), but the built-up deposits may start at any point in their development, and through the influence of certain outside agencies, they may be permanently arrested at any stage, so that only one or two typical plant

⁷Bergman, H. F., unpublished manuscript, University of Minnesota.

associations will be represented in the bog. This is why there are so many large peat bogs in northern Minnesota which are built up on flat surfaces chiefly from the remains of a single plant species.

The commonest plant remains found in the peat deposits which have originated in this manner are those of sphagnum, sedges and grasses. These are never mixed in the same layers of peat. Oftentimes the peat in a given bog will consist almost entirely of sphagnum, especially in the coniferous forest region. In the prairie region, the peat in these built-up deposits consists almost entirely of sedges and grasses. Where both sphagnum and sedges occur in the same deposit the sphagnum always is found in layers overlying the sedge peat.

The plants now found growing on these built-up bogs are, in many cases, the same as those from which the peat in the deposit has formed. In other instances the bogs have passed into a more advanced stage, and plant associations of heaths and sphagnum, or tamarack and spruce are found growing on peat consisting mostly of sedge remains or layers of sedge peat, covered with sphagnum peat. The largest built-up bogs in the coniferous forest regions of the north are now in the tamarack-spruce stage, or bog-heath-sphagnum stage. These built-up deposits, when in such advanced stages of development, cannot be distinguished from the filled-lake bogs by any surface indications. Their true nature can only be ascertained by the study of the plant remains in the peat, and by a careful determination of the character and topography of the bottom of the bog by means of numerous test holes.

As already pointed out, under certain conditions of water level, peat may be built up layer by layer on top of filled-lake deposits. These bogs may also show the same plant associations as those now growing on the surface and hence it is usually impossible to determine the history of any given bog in the northern part of North America from a casual inspection of the vegetation growing on the surface.

PHYSICAL AND CHEMICAL PROPERTIES OF MINNESOTA PEAT—COLOR.

The prevailing color of Minnesota peat is brown. Dark brown predominates, while light yellowish-brown is a common shade. The pond peat, composed of aquatic plants, is nearly always a greenish, varying from yellowish-green to

greenish-brown. In a few deep bogs, peat of a straw-yellow color was found near the bottom. All the peat, regardless of the color, turns a darker shade within a few minutes after being dug and exposed to the air. Black peat occurs in the bottom layers of some of the deposits, but only a few such instances were noted.

TEXTURE.

The texture of the peat also varies greatly, and is dependent upon (1) the type of plant composing the peat; (2) the manner in which the deposit was formed; and (3) the degree of decomposition. The commonest texture in the Minnesota deposits is fibrous or mossy. The upper layers of all the deposits are distinctly fibrous. In some of the open sedge bogs the upper portion of the peat is spongy. The sphagnum peat is mossy. This fibrous or mossy peat extends downward for variable distances depending upon the types of plants composing the middle and lower layers of the deposits, and upon the amount of decomposition which has taken place. The bottom layers are often well decomposed, and the fibrous texture is destroyed.

CHEMICAL COMPOSITION AND FUEL VALUE.

The following table of analysis shows the chemical composition and fuel value of 29 samples of typical peat from northern Minnesota. The most noteworthy features of the analyses are the high average nitrogen content of the peat, and the comparatively low ash content, both of which indicate peat of excellent quality for fuel. The composition and fuel values compare favorably with those of peat from other regions both in the United States and in Europe.

Distribution and Quantity of Peat in Minnesota.

The peat deposits of Minnesota fall into three more or less distinct groups: (1) in the northern part of the state, the so-called "muskeg swamps," occur chiefly in Beltrami, Koochiching, St. Louis, Itasca, Roseau, Aitkin, Crow Wing, Cass, and Clearwater counties; (2) in the central part of the state, the largest and best deposits are in Rnoka, Ramsey, Wright, Hennepin, Stearns, Sherburne, Isanti, Washington, Chisago, Millelacs, and Douglas counties; and (3) in southern Minnesota, principally in Blue Earth, Nicollet, Le Sueur, Rice, Scott, Carver, Dakota, Steele, Freeborn, and Waseca counties.

The only areas in Minnesota which do not contain peat deposits are: (1) the "driftless area" in the extreme

ANALYSES OF SOME PEAT SAMPLES FROM MINNESOTA.
 (Analyses by United States Bureau of Mines.)

Locality. County.	No. Analy- sis	Moisture Content Receiv'd.	Proximate.				Ultimate.				Thermal Value B. T. U.		
			Vola- tile Matter.	Fixed Car- bon.	Ash.	Sul- phur.	Nitro- gen.	Hy- dro- gen.	Car- bon.	Oxy- gen.	Moisture and Ash Free.		
St. Louis	188	10	14.33	59.82	26.66	1.352	.29	1.63			7.862	9,091	
	189	11	12.65	60.82	26.01	13.17	.29	2.16			8,490	9,778	
	190	12	14.05	60.71	20.85	18.44	.52	1.65			7,466	9,154	
	191	18	14.58	65.73	23.97	10.30	.28	2.62			8,950	9,978	
	192	19	26.43	62.62	20.69	16.69	.24	2.26			8,289	9,949	
	193	20	14.53	64.96	25.04	10.00	.25	2.49	4.83	53.88	28.55	8,896	9,884
	194	21	13.45	67.51	24.40	8.09	.24	2.58	5.23	53.24	30.62	9.153	9,959
	21a	21a	40.35	69.66	20.37	9.97	.34	2.35			8,899	9,884	
	195	22	12.48	66.64	24.79	8.57	.26	2.38			9,149	10,006	
	196	23	13.38	65.65	24.16	10.19	.18	1.93			8,698	9,685	
	197	23	13.38	66.22	23.45	10.33	.14	1.76			8,930	9,959	
	198	24	24.00	66.62	24.62	13.43	.29	1.68			8,150	9,415	
	199	25	20.10	61.95	22.94	15.43	.31	1.95			8,098	9,575	
	200	26	16.73	61.63	22.94	15.43	.31	2.35			8,403	10,014	
	201	27	12.80	61.50	22.41	16.09	.31	2.68			8,902	10,114	
	202	28	14.20	64.25	23.77	11.98	.31	2.67			7,953	9,771	
	203	29	36.60	62.98	18.91	18.11	.25	2.03			8,762	9,992	
	204	30	9.83	63.62	24.07	12.31	.30	2.64			8,620	9,906	
	205	31	11.03	66.54	24.88	8.58	.26	2.69			8,637	9,955	
	206	32	10.78	74.17	22.60	13.23	.21	2.68			8,351	9,832	
	207	33	13.55	62.06	22.87	15.07	.22	2.73			8,649	9,887	
	208	34	16.83	63.91	24.01	12.08	.37	2.56			8,409	9,863	
	209	35	16.53	60.98	24.28	14.74	.29	2.34			8,620	9,936	
	210	36	40.35	65.72	21.04	13.24	.28	2.43			8,620	9,936	
	211	37	12.60	68.97	23.84	7.18	.21	2.17			8,240	9,188	
	212	38	10.20	63.81	27.92	8.27	.15	4.74			8,240	9,188	
	213	39	12.10	66.15	25.20	8.65	.23	1.75			9,146	10,012	
	214	40	11.63	60.15	23.84	16.01	.65	2.32			8,620	9,936	
	215	41	9.25	58.90	17.13	23.97	.37	2.62			8,620	9,936	
	216	41a	9.83	67.26	22.67	10.07	.40	1.80			8,620	9,936	

southeastern part of the state; (2) an area in the Red River Valley in the extreme northwestern corner; and (3) a narrow strip along the boundary between Minnesota and North and South Dakota, on the extreme western edge of the state.

From the investigations made by the writer for the Minnesota Geological Survey, it is estimated that Minnesota had originally about 7,000,000 acres of peat land containing peat deposits varying in thickness from a few inches to 30 feet or more. Of this great area, about 5,217,000 acres are covered with peat at least 5 feet thick (the minimum workable depth). The total quantity of peat available for machine peat fuel of good quality in Minnesota, occurring in deposits 5 feet or more thick, estimated on a basis of 200 tons of air-drying machine peat per acre-foot of peat, is approximately 6,835,300,000 short tons.

If this peat were converted into machine peat bricks and sold at \$3.00 per ton, it would have a value of \$20,505,-900,000.

The largest and best peat fuel deposits in Minnesota occur in St. Louis, Koochiching, Beltrami, Itasca, Aitkin, Carlton, and Roseau counties—all in the northern part of the state. There are many hundreds of smaller bogs scattered throughout nearly every county in central and northern Minnesota, most of which contain good fuel peat.

While most of the peat deposits are now too remote from railroads to offer immediate commercial possibilities, there are nevertheless hundreds of thousands of acres of peat fuel deposits of the highest quality which are crossed by railroads.

Possible Uses of Minnesota Peat—Peat Fuel.

One of the most important problems in northern Minnesota at the present time concerns the most profitable commercial use that can be made of the peat deposits of that region. It seems probable that the manufacture of power in peat producer-gas plants will soon be attempted, and there seems to be an unusual opportunity in Minnesota for success in that field, especially near the iron-mining districts. Such power has been successfully produced in a number of large plants in Europe, and there seems to be no reason why their success cannot be duplicated here.

There is also an attractive field in Minnesota for the manufacture of machine peat for domestic fuel.

Although there are no commercial plants for the manufacture of peat fuel in the United States at the present time, it is probable that the industry will develop in this

country within a few years, as it has been developed to a high degree in Europe. A large experimental peat fuel plant was recently operated at Alfred, Ontario, by the Canada Department of Mines,⁸ and after the manufacture of machine peat was proved to be commercially successful, the plant was taken over by private interests. Plate XXXIV. shows two views of the Ontario peat fuel plant. The peat used at the Ontario plant was identical in quality with that found at numerous localities in northern Minnesota.

Modern peat fuel is made by special machinery and the product, which is put on the market in the shape of blocks, or bricks, similar to stove wood in size, shape and weight, is called machine peat. This is the type of peat-fuel which has proved to be a commercial success in Europe and in Canada, and which will probably form the basis of any peat fuel industry which may develop in this country in the future.

Numerous plants have been built to manufacture peat briquettes but none of these attempts have as yet proved to be commercially successful. The chief difficulty to be overcome seems to be the high cost of eliminating the moisture from the raw peat by any method of artificial drying. Machine peat is dried in the sun.

By-Products from Manufacture of Producer-Gas.

The principal by-product which can be obtained from the manufacture of producer-gas is ammonium sulphate $(\text{NH}_4)^2\text{SO}_4$, which, because of its high nitrogen content, is in great demand as a fertilizer. Theoretically, 1 short ton of dry peat containing 1 per cent. nitrogen will yield 94 pounds of ammonium sulphate. In the European plants the recovery is about 75 per cent., i. e., approximately 70 pounds of ammonium sulphate are produced per short ton of peat burned, calculated on a moisture-free basis.

Agricultural Uses of Peat.

The possibility of using the large tracts of shallow peat land in northern Minnesota for agriculture is of the greatest importance, and the industrial future of several entire counties in the northern part of the state depends to a large extent upon the uses which can be made of the peat deposits there. Already a large acreage of peat land is under cultivation. The results of experiments made in this country and at European peat experiment stations show that peat soils will produce satisfactory crops of forage plants,

⁸For descriptions of various types of peat machines, and peat manufacturing processes, see Bulletin 16, U. S. Bureau of Mines, and Publications 151, 154, 266, 299, Mines Branch, Canada Department of Mines.

EXPLANATION TO PLATE XXXI.

A. Looking along drainage ditch through a typical tamarack swamp of northern Minnesota. Peat is two to seven feet thick. Note plat spread out for road-bed.

B. View along newly constructed road through dense black spruce swamp, northern Minnesota. Peat is about five feet thick.
Plate XXXI. Economic Geology. Vol. XII.

A



B

EXPLANATION TO PLATE XXXII.

A. Peat deposit of the filled lake type, northern Minnesota. Note the old shore line. Peat is four to ten feet thick.

B. View along drainage ditch through big open peat bog in northern Minnesota with tamarack zone in the distance. Note the peat on the spoil bank of the ditch, which is levelled off for a wagon road. Peat is seven to twenty feet thick.

Plate XXXII.

Economic Geology. Vol. XII.



A



B

EXPLANATION TO PLATE XXXIII.

A. Pond-lily and sedge zones around peat-forming lake in Itasca County, Minnesota.

B. Zones of bulrushes and giant sedges around border of a peat-forming lake in southern Minnesota. Note floating mat of vegetation in immediate foreground.

Plate XXXIII.

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A



B

EXPLANATION TO PLATE XXXIV.

A. Peat machine (Moore System) in operation at Alfred, Ontario.
(Photo by E. V. Moore.)

B. View showing method of spreading and drying machine peat on the bog (Moore System) at the Alfred plant, Alfred, Ontario. The row on the left has been cross cut into blocks, while the row in the center has just been spread. Note peat machine in the distance and trolley for operating spreader to the right. (Photo by E. V. Moore.)

Plate XXXIV.

Economic Geology. Vol. XII.



A

small grains, and all ordinary vegetables except asparagus, with proper cultivation, and fertilization. There are, however, certain limitations upon the profitable cultivation of peat bogs.⁹ These are: (1) drainage, (2) depth and character of peat, (3) climate, (4) transportation facilities, and (5) expense of marketing the products.

Other Uses.

The possibility of using peat in the iron-ore industry of Minnesota has been suggested by Professor Peter Christianson, of the Minnesota School of Mines. The possible appli-

⁹"Limitations on the Cultivation of Peat Lands in Minnesota," F. J. Always, Journal American Peat Society, April, 1916. p. 65.



B

cations, as suggested by Professor Christianson, are: (1) the use of peat for power; (2) the use of peat for heating operations in drying, roasting, sintering or calcining; (3) the use of peat as a binder in ore briquetting; and (4) the possible use of peat coke or charcoal in smelting.

Peat is extensively used in the United States as a fertilizer filler, in which capacity it is said to improve the fertilizer both chemically and mechanically. It is also used in this country to a considerable extent for stable litter and packing material. The fibrous and mossy peats of Minnesota would be especially suitable for such uses. Other uses for peat are: for paper stock, woven fabrics, ammonium compounds, artificial wood, manufacture of nitrate, dye stuffs, materials for tanning, and sanitary and medicinal uses.

INORGANIC COMPOSITION OF A PEAT AND OF THE PLANT FROM WHICH IT WAS FORMED.*

By C. F. Miller, Scientist in Chemical Investigations, Bureau of Soils, United States Department of Agriculture.

Introduction.

The comparison of the inorganic composition of a peat with that of the material from which it was formed can seldom be made with any certainty, because generally several species of plants have contributed to the deposit. The extensive saw-grass peat deposits found in the Everglades of Florida offer an unusual opportunity to make this comparison, since all indications point to their having been formed by the accumulation of the remains of a single species of plant, saw grass (*Cladium effusum*).

Description and Composition of Saw Grass.

Saw grass is a member of the sedge family and is found chiefly along the banks of streams or ponds and in swamps throughout the southeastern States. By far the largest colony is found in the Everglades, where many thousand acres are covered with an almost impenetrable growth, which reaches a height of 8 to 10 feet in many places. Saw grass resembles ordinary grasses in appearance and derives its name from the fact that the edges and back of the midrib of the leaves are serrated.

On account of the difficulty experienced in obtaining entire plants for analysis, separate samples of leaves, root crowns, and roots were gathered, care being taken to remove all extraneous material. In ashing the samples an electric muffle furnace, fitted with an automatic temperature control set at 550° C., was used to prevent the loss of alkalies by volatilization.

The determination of silica was made according to the method of the Association of Official Agricultural Chemists,¹ the figure stated thus representing silica constitution only. Phosphoric acid and the alkalis were determined in the usual

*Reprint from Journal of Agricultural Research, 1918, Vol. 13, p. 605.

¹Wiley, H. W., ed. Official and Provisional Methods of Analysis, Association of Official Agricultural Chemists, as compiled by the Committee on Revision of Methods. U. S. Dept. Agr. Bur. Chem. Bul. 107, p. 22. 1907.

manner, and the remaining constituents by the modified Glaser method described by Mellor.² The significance of separate values for iron and aluminum ovids was not deemed of importance, and therefore they are reported together. A test was made for titanium, but it was not found in any part of the saw-grass plant. The results of the analyses are given in Table I.

TABLE I.—Composition of Saw Grass.

Constituent.	Percentage of dry material.			
	Leaves.	Crowns.	Roots.	Average.
Silica (SiO_2)	0.50	0.32	0.10	0.30
Iron ovid (Fe_2O_3) and alumina (Al_2O_3) ....	.09	.08	.16	.11
Lime (CaO}) .....	.59	.59	.52	.57
Magnesia (MgO}) .....	.12	.12	.10	.11
Soda (Na_2O}) .....	.27	.06	.14	.16
Potash (K_2O}) .....	.39	.31	.35	.35
Phosphoric acid (P_2O_5) .....	.08	.09	.05	.07
Nitrogen .....	.90	.89	.62	.80

It will be noted that there is comparatively little variation in the composition of the three parts of the plant, with the possible exception of the silica content, and therefore the average of the values found for the three parts is taken as the composition of the saw grass for the subsequent comparisons. The values given are very near the true ones, even in the case of the silica, since it is probable that leaves and roots contribute in nearly equal amounts in the formation of peat.

Description and Composition of Peat.

The peat deposit in the Everglades resulting from the accumulation of the remains of saw grass and varying in depth to about 10 feet, covers a vast area. Near the surface the peat is brown in color, has a loose, fibrous structure, and is very light when dry. It has an ash content of from 7 to 10 per cent. At depths below the surface the material becomes darker in color and less fibrous in texture as the depth increases, grading finally into a black, plastic, compact mass almost free from plant fiber. The ash content also increases slightly with the depth, but even at depths of 6 or 7 feet no free mineral matter can be detected, except in limited areas where extraneous sand or calcium carbonate contaminate the material.

The samples used in this investigation are representative

²Mellor, J. W. A Treatise on Quantitative Inorganic Analysis. p. 606-609. London, Philadelphia, 1913.

of about 12 taken from widely separated areas and can be looked upon as being typical of the peat deposit in the Everglades. Sample 1 was taken 9 miles from Lake Okeechobee near the North New River Canal at a depth of 0 to 60 inches. No. 1a is the subsoil of No. 1, its depth being 60 to 120 inches. Sample 2 was taken 20 miles from Lake Okeechobee, a few miles from the North New River Canal, at a depth of 0 to 25 inches, while No. 2a, its subsoil, represents the depth from 25 to 82 inches.

Analyses of this peat were made by practically the same methods used in the case of the ash of the saw grass. The results are presented in Table II.

TABLE II.—Composition of Everglades Peat.

Constituent.	Peat 1.	Peat 2.	Peat 1a (subsoil of 1).	Peat 2a (subsoil of 2).a
Silica	1.95	2.04	1.98	3.02
Iron oxid and alumina .....	.69	.60	.93	1.12
Lime	3.02	2.74	4.67	4.27
Magnesia .....	.43	.44	.45	.70
Soda .....	.14	.19	.19	.25
Potash .....	.11	.06	.09	.06
Phosphoric acid .....	.13	.15	.07	.07
Nitrogen	3.32	3.84	2.83	2.75
Total ash	7.7	6.8	8.8	10.2

a This sample contained a small amount of extraneous sand.

Comparison of Peat and Saw Grass Analyses.

In comparing a soil with its parent substance in order to determine the amount of the various constituents removed during the transformation it must be assumed that one of the elements present was not removed at all, or at any rate to a slight extent only. Thus, Merrill¹ compares a granite rock with its resultant clay and assumes that the alumina content was unaltered, while Penrose² in comparing a limestone with its resultant clay assumes that no silica was lost during the change. In the present instance the silica was used as the basis of calculation, because it is undoubtedly the most stable constituent present under the conditions of peat formation—that is, continual submersion in water. Table III shows the relationship between the peat and the saw grass when the latter is calculated to the same silica content.

¹Merrill, G. P. Weathering of Micaceous Gneiss in Albemarle County, Virginia. In Bul. Geo. Soc. Amer., v. 8, p. 160. 1897.

²Penrose; R. A. F. Manganese; Its Uses, Ores, and Deposits. Ann. Rept. Geo. Survey Ark. 1890, v. 1, p. 179. 1891.

TABLE III.—Comparison of the Composition of Peat and Saw Grass.

Constituent.	Saw grass	Per- cent- age loss.	Saw grass	Per- cent- age loss.		
	× silica ratio		Peat 1. (6.5).			
Silica	1.95	0.0	2.04	2.04	0.0	
Iron oxid and alumina.....	.69	.72	.60	.75	20.0	
Lime	3.02	3.70	18.4	2.74	3.88	29.3
Magnesia .....	.43	.72	40.3	.44	.75	41.3
Soda .....	.14	1.04	86.5	.19	1.09	82.6
Potash .....	.11	2.27	95.1	.06	2.38	97.5
Phosphoric acid .....	.13	.45	71.1	.15	.48	68.7
Nitrogen	3.32	5.20	36.1	3.84	5.44	29.4

The losses obtained for the two samples of surface peat cited agree very well except in the case of the iron oxid and alumina, and even here the variation is not excessive. No comparison was made with the subsoil peats because they have been subjected to the leaching action of water so long that more or less of all the elements present must have been removed. In the subsoil 1a there appears to have been a considerable loss of silica, while both samples contain much less nitrogen than those taken from nearer the surface. However, this is to be expected when it is considered that hundreds, if not thousands, of years have elapsed since the deposition of these lower strata.

The comparatively small loss of lime suffered by the saw grass may seem surprising at first, and it is unusual, as this constituent is leached very readily from ordinary soils. There are two possible explanations for its behavior under the circumstances. In the first place, the lime is present in the plant for the most part as difficultly soluble compounds (calcium oxalate, etc.), and in the second place, owing to the great abundance of calcium carbonate in the Everglades, the solvent action of the waters upon the lime in the peat must be far less than it would be under other conditions.

In the formation of ordinary soils, potash is held by absorption, and, hence, suffers a lower percentage loss than some of the less soluble elements; but this constituent is leached very readily from leaves and vegetation,¹ and nearly the entire amount originally present in the saw grass has been removed in the transformation to peat.

¹Le Clerc, J. A., and Brezeale, J. F. Plant Food Remover from Growing Plants by Rain or Dew. In U. S. Dept. Agr. Yearbook, 1908, p. 389-402. 1909.

The enormous accumulation of nitrogen in the peat is an interesting phase of the change undergone by the saw grass. The loss of nitrogen seems to be very gradual, and even in the subsoil there is still a very high percentage of this element. The prevailing poor conditions for bacterial activity while the peat is being formed both preclude the possibility of nitrogen fixation, and also account for the greater stability of the nitrogen in the peat than in ordinary soils, wherein the nitrogen is oxidized to nitrate and thus leached.

In Table IV a comparison is made of the losses suffered by three widely differing soil-forming materials in their transformation to soils. As previously stated, the behavior of the lime in the saw grass is strikingly different from that in the other cases cited and considerably more potash also was removed.

TABLE IV.—Comparison of the Losses of Three Soil-forming Materials in Their Transformation to Soils.

Constituent.	Percentage losses suffered by parent material in soil formation.		
	Arkansas limestone (8 parts yield 1 of soil).a	Granite (1.7 parts yield 1 of soil.)b	Saw grass (7 parts yield 1 of peat.).
Silica	0.00	52.45	0.00
Iron oxid	89.56	14.35	12.2
Alumina	11.35	00.00	
Lime	98.93	100.00	23.8
Magnesia	89.38	74.70	40.8
Potash	66.36	83.52	96.3
Soda	53.26	95.03	84.6
Nitrogen			32.8

a Penrose, R. A. F. Loc. City.

b Merrill, G. P. Loc. City.

Conclusions and Summary.

In this article the inorganic composition of typical samples of Everglades peat is given together with analyses of the parent material from which the peat was formed—namely, saw grass (*Cladium effusum*). Brief descriptions of both produces are also given. Assuming that no silica was lost during the transformation, about 7 parts of saw grass were required to yield 1 of peat. Based on this assumption, the constituents were leached to the following extent:

Iron oxid and alumina, 12.2 per cent; lime, 24 per cent; magnesia, 41 per cent; potash, 96 per cent; soda, 84.6 per cent; phosphoric acid, 70 per cent; and nitrogen, 33 per cent. The losses suffered by two other common soil-forming substances, granite and limestone, are shown for the sake of comparison.

PEAT WOOL.

Last fall we mentioned that people in Sweden were investigating the proposition of using peat fiber as a substitute material in the textile industry. On the initiative of Prof. G. Sellergren, of the Technical High School in Stockholm, the question was taken up for investigation, and this has given such results that a stock company has been formed, under the name "Fiberuld" (which is what the Swedes call the new material), and is now equipping a factory at Hadenge in Jonkoping Len for spinning fiber of peat taken from the large bogs there. After many experiments an economical method of extracting peat fiber or peat litter has been worked out. The fiber obtained will be dealt with further, carded, spun and woven in a factory which the company is establishing near Goteborg.

The peat wool can be made into matting, carpet stuffs, etc., in various colors, while by mixing in 10 per cent of animal hair, it can be used for felt soles in footwear. The most surprising development is the weaving of cloth, in order to do which 30 to 40 per cent of wool is mixed in. This product can hardly be distinguished from cloth made from wool alone, so soft is the feel of it. The strength is such that while wool thread can bear 9 kilos (19.8 pounds) the fiber-wool thread can bear 13 kilos (28.7 pounds), which also shows that the fiber wool is usable for binder twine.

Cost of Production.

According to calculations the fiber wool can be produced for 40 ore per kilo (\$0.107 per 2.2046 pounds or \$0.0486 per pound), which shows that 3 kilos containing one part clean wool and two parts of fiber wool will cost at present 8.80 crowns (\$2.36) while 3 kilos of wool alone costs 24 crowns (\$6.43). The peat that can not be used for "wool" can be used as peat litter (70-75 per cent) or made into briquets for fuel.

The method, with the necessary machinery, is patented in Sweden. We understand the rights have been bought by a Danish syndicate, and one can reckon that in the near future peat fiber will also be produced in Denmark in connection with one of the largest textile mills. The machine question can easily be solved, so that the matter will not meet with difficulties in that way.—Consular Report.

WATER HOLDING CAPACITY OF PEAT COMPARED WITH OTHER BEDDING MATERIALS.

We are frequently called upon for figures giving the comparative absorption of peat and other materials and we therefore publish herewith a table showing the liquid absorbing capacities of various substances which appear in *Traite de Chemie Agricole* of P. P. Deherain, published in Paris in 1902.

Kind of Litter.	Water retained by 100 kgm. of material after 24 hours. kgm.	Quantity of material necessary to re- place 100 kgm. of wheat straw. kgm.
Wheat straw	220	100
Barley straw	285	77
Oat straw	228	96
Partially decomposed oak leaves.....	162	136
Peat	500-700	40
Sawdust of poplar wood.....	435	50
Spent tan bark.....	400-500	48
Air-dried vegetable mold.....	50	440

U. S. PEAT INDUSTRY FOR 1917.

The peat industry in the United States was prosperous in 1917, for the quantity of peat sold exceeded that sold in any preceding year. According to statistics compiled by C. C. Osborn, of the United States Geological Survey, Department of the Interior, the peat sold in 1917 amounted to 97,363 short tons, a quantity greater by 44,857 tons, or about 85 per cent, than that sold in 1916, and by 42,220 tons, or nearly 77 per cent, than the record annual sales, 55,143 tons, established in 1911.

The average price received for peat in 1917 at the point of consumption was a little more than \$7.29 a ton, and the gross market value of the output was \$709,900, a gain over 1916 of 26 cents in average price per ton, and of \$340,796, or about 92 per cent, in market value.

The following table shows by years the output and value of peat marketed from bogs in the United States each year since 1908:

Peat Sold in the United States, 1908-1917.

Year.	Quantity (short tons).	Value.
1908.....	a24,800	a\$136,610
1909.....	29,167	127,042
1910.....	37,024	140,209
1911.....	55,143	272,114
1912.....	47,380	228,572
1913.....	33,260	197,200
1914.....	47,093	309,692
1915.....	42,284	288,537
1916.....	52,506	369,104
1917.....	97,363	709,900

a Estimated.

The total number of plants producing peat in the United States in 1917 was 18, an increase of 5 over 1916. All the producers operating in 1916 except two contributed to the output in 1917, and seven companies that were not represented in that year reported commercial production. Many new companies were organized in 1917 that did not complete their plants in time to contribute to the year's output. The plants known to be at work in 1917 were distributed as follows: California, 2; Florida, 2; Illinois, 2; Indiana, 1; Massachusetts, 1; New Jersey, 5; New York, 3; Pennsylvania, 1; and Virginia, 1.

All the producers reported that the demand for peat exceeded the supply, and some stated that, on account of railroad embargoes and the scarcity of labor, they were unable to meet the demands of their regular customers. Improvements designed to increase production in 1918 were made to substantially all the peat plants operated in 1917.

(U. S. Geo. Survey.)

PEAT IN CANADA—1916.

The total shipments of peat during 1916 were 300 tons, valued at \$1,500, all from a bog in Middlesex County, Ontario, operated by The Dorchester Peat Fuel Co., Ltd.

In 1915 shipments were made from the Alfred bog, Prescott County, amounting to 300 tons, valued at \$1,050.

Statistics of the annual production of peat since 1900 are given in the following table:

Annual Production of Peat.

Calendar Year.	Tons.	Value.	Calendar Year.	Tons.	Value.
1900.....	400	\$1,200	1909.....	60	\$ 240
1901.....	220	600	1910.....	841	2,604
1902.....	475	1,663	1911.....	1,463	3,817
1903.....	1,100	3,300	1912.....	700	2,900
1904.....	800	2,400	1913.....	2,600	10,100
1905.....	80	260	1914.....	685	2,470
1906.....	474	1,422	1915.....	300	1,050
1907.....	50	200	1916.....	300	1,500
1908.....	60	180			

Determination of Free and Combined Humus in Peat and Sandy Soils (N. L. Sohngen, A. Knetman & K. T. Wieringa) (Chem. Weekblad. 1918—vol. 15, p. 406.) The percentage of free humic acid in peat and sand soils, and their Calcium requirement, can be determined more or less accurately by the nitrifying bacteria culture method, or better by the method of diffusion in agar-agar with an indicator. The latter is a general method for titrating turbid or opaque liquids; the sensitivity is 1 to 50,000 normal. It is also valuable for determining how much marl is to be added to an acid soil to make it normal and yet not alkaline. Determinations of Hydrogenion concentration or of conductivity do not give good results. A modification of Tacke's method gave results agreeing closely with the diffusion and bacteria culture methods. The humus in soils is to be regarded as complex mixture of related compounds with a certain number of acid groups. The amount of humic acid per gram of ignition loss, in all the investigated sand and peat soils, was equivalent to about 80 mg. of Calcium carbonate except for uncleared lands rich in humus. Humus has colloidal properties. The actual cause of the 2 types of soil deficiency was not determined by this investigation; but it was established that a direct relation exists between the occurrence of such deficiencies and the percentage of free humic acid.

The Effect of Heat on the Nitrogen in Peat Soils. R. S. Potter and R. S. Snyder (Soil Science 1918—vol. 5, p. 197.) Two silt loams and a peat were heated at different temperatures and under varying pressure and incubated different periods to determine the effect on the Nitrate, Ammonia, amino-acid Nitrogen and the soluble non-protein Nitrogen. The amount of Ammonia was increased by all the heat treatments, the higher the temperature the greater the increase

in Ammonia. With the peat not as much change was brought about by heat in Ammonia formation nor in amount of amino acid Nitrogen. Dry heat at 100°C produced only small change in Nitrate content. A temperature of 200°C caused the total disappearance of Nitrate. Soluble non-protein Nitrogen was increased by each heat treatment. The least change was again made in the peat soil, which is probably due to the escape of Ammonia from the soil at the higher temperature treatments. In the three mineral soils heated to 10 lbs. for 9 hrs. with 10 weeks' incubation after inoculation with fresh soil there was an increase in Ammoni. There was less increase in the 25 weeks' incubation period. Ten weeks' incubation caused a decrease in amino Nitrogen, there being a larger amount at the end of 20 weeks. Nitrate was increased, the larger period giving the greater increase. The amount of non-protein Nitrogen was changed only slightly by incubation of the mineral soils heated to 10 lbs. In the peat soil 20 weeks' incubation lessened the amount of this group.

ANALYSES OF CANADIAN PEAT.

In bulletins Nos. 22, 23 and 24, the Mines Branch, Ottawa, Canada, have published the analyses of several peat deposits in the provinces of Nova Scotia, Prince Edward Island, New Brunswick, Quebec, Ontario and Manitoba, which we herewith publish.

Nova Scotia Peat Bogs.

Description.	Cherryfield bog,								
	Caribou bog, Berwick,* King's county.			Cherryfield† Lunenburg county.			Clyde bog, Clyde River, Shelburne county.		
Sample No.	501	502	503	504	509	510	511	512	
Moisture con. (see note) ..	D	D	D	D	D	D	D	D	
Loss on air-drying .....	...	...	...	...	...	...	...	...
Proximate analysis:—									
Moisture	%	7.7	4.4	2.9	2.0	6.1	7.0	5.4	3.2
Ash	%	26.6	64.7	66.7	67.5	64.1	64.0	64.8	66.4
Volatile matter.....	%	29.7	30.9	30.4	39.5	29.8	29.0	29.8	30.4
Fixed carbon.....	%	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
Ultimate analysis:—									
Carbon	%	1.6	1.2	1.0	0.9	1.1	1.4	1.1	1.1
Hydrogen	%	1.47	0.48	0.46	0.45	0.47	0.45	0.46	0.46
Ash	%	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
Sulphur	%	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Nitrogen	%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Oxygen	%	52.50	52.80	51.50	52.60	51.50	52.70	52.60	
Calorific value:—									
Calories per gram, gross....	5440	5410	5300	5320	5250	5280	5150	5260	
B. Th. U. per lb., gross....	9790	9740	9550	9580	9450	9510	9270	9460	
Fuel ratio	0.47	0.48	0.46	0.45	0.47	0.45	0.46	0.46	
Carbon-Hydrogen ratio.....	...	...	...	...	...	...	...	...
Coking properties .....	...	...	...	...	...	...	...	...
Kind of sample—All prospect.									
Taken by—All by A. Anrep, Mines Branch, Ottawa.									
Date of sampling—All during summer of 1914.									
Remarks—*Bog traversed by Dominion Atlantic railway. †Bog traversed by Halifax & Southwestern railway.									

Nova Scotia Peat Bogs.

Description.	Clyde bog, Clyde River Shelburne county.		Port Clyde bog, Port Clyde† Shelburne county.		Latour bog, Port Latour Shelburne county.		
	513	514	517	518	522	523	
Sample No.	D	D	D	D	D	D	
Moisture condition (see note)...	...	...	...	...	...	...
Loss on air-drying	%	4.9	4.3	3.0	3.4	3.8	4.0
Proximate analysis:—							
Moisture	%	62.8	66.4	66.6	66.5	68.0	67.9
Ash	%	32.3	29.3	30.4	30.1	28.2	28.1
Ultimate analysis:—							
Carbon	%	0.3	0.3	0.3	0.3	0.3	0.3
Hydrogen	%	1.2	1.2	1.1	1.1	1.1	1.1
Ash	%	0.3	0.3	0.3	0.3	0.3	0.3
Sulphur	%	0.3	0.3	0.3	0.3	0.3	0.3
Nitrogen	%	0.1	0.1	0.1	0.1	0.1	0.1
Oxygen	%	5400	5280	5340	5150	5170	
Calorific value:—							
Calories per gram, gross....	5430	5280	5400	5340	5150	5170	
B. Th. U. per lb., gross....	9780	9510	9730	9610	9280	9310	
Fuel ratio	0.52	0.44	0.46	0.45	0.42	0.41	
Coking properties .....	...	...	...	...	...	...
Location in bog.....	...	...	...	...	...	...

Kind of sample—All prospect.

Taken by—All by A. Anrep, Mines Branch.

Date of sampling—All during summer of 1914.

Remarks—†Bog traversed by Halifax & Southwestern railway.

NOTE—Figures in column D refer to peat dried at 105°C.

Nova Scotia Peat Bogs.

Description.	The Heaths bog, Lower Argyle,† Yarmouth county.				Makoke bog Tusket, Yarmouth county.		Tusket bog, Tusket,† Yarmouth county.	
	505	506	507	508	515	516	520	521
Sample No.	505	506	507	508	515	516	520	521
Moisture condition, (see note, p. 254)	D	D	D	D	D	D	D	D
Loss on air-drying . . . . %	...	...	...	...	...	...	...	...
Proximate analysis:								
Moisture %	8.9	9.6	4.5	4.9	6.1	4.3	12.1	7.7
Ash %	60.9	63.2	65.6	67.5	65.6	67.0	59.5	62.5
Volatile matter %	30.2	27.2	29.9	27.6	28.9	28.7	27.8	29.8
Ultimate analysis:								
Carbon . . . . %	...	...	...	...	...	...	...	...
Hydrogen . . . . %	...	...	...	...	...	...	...	...
Ash %	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5
Sulphur %	1.7	1.6	1.4	1.5	1.6	1.5	1.8	1.6
Nitrogen . . . . %	...	...	...	...	...	...	...	...
Oxygen . . . . %	...	...	...	...	...	...	...	...
Calorific value:								
Calories per gram, gross	5230	4950	5410	5490	5180	5280	5070	5210
B. Th. U. per lb., gross	9410	8890	9740	9890	9320	9510	9130	9380
Fuel ratio	0.50	0.43	0.46	0.41	0.44	0.43	0.47	0.48
Carbon-Hydrogen ratio . . . .	...	...	...	...	...	...	...	...
Coking properties . . . .	...	...	...	...	...	...	...	...
Kind of sample—All prospect.								
Taken by—All by A. Anrep, Mines Branch.								
Date of sampling—All during summer of 1914.								
Remarks—†Bog traversed by the Halifax and Southwestern railway.								

Prince Edward Island Peat Bogs.

Description.	Mermaid bog, 5 miles N. E. of Charlottetown, Queen's county.		Miscouche bog, St. Nicholas Station,* Prince county.		Black Marsh bog, 6 miles north of Tignish, Prince county.	
	443	444	499	500	497	498
Sample No.	443	444	499	500	497	498
Moisture condition (see note, p. 254)	D	D	D	D	D	D
Loss on air-drying . . . . %	...	...	...	...	...	...
Proximate analysis:						
Moisture %	3.6	4.9	5.7	8.3	4.4	5.3
Ash %	67.1	65.8	62.8	62.7	64.5	65.8
Volatile matter %	29.3	29.2	31.5	29.0	31.1	28.9
Ultimate analysis:						
Carbon . . . . %	...	...	...	...	...	...
Hydrogen . . . . %	...	...	...	...	...	...
Ash . . . . %	...	...	...	...	...	...
Sulphur %	0.9	1.2	1.3	1.4	0.8	0.9
Nitrogen . . . . %	...	...	...	...	...	...
Oxygen . . . . %	...	...	...	...	...	...
Calorific value:						
Calories per gram, gross	5320	5520	5300	5170	5480	5440
B. Th. U. per lb., gross	9580	9940	9550	9300	9866	9790
Fuel ratio	0.44	0.45	0.59	0.46	0.48	0.44
Carbon-Hydrogen ratio . . . .	...	...	...	...	...	...
Coking properties . . . .	...	...	...	...	...	...
Kind of sample—All prospect.						
Taken by—All by A. Anrep, Mines Branch.						
Date of sampling—All during summer of 1914.						
Remarks—*Bog traversed by Canadian Government railway.						

New Brunswick Peat Bogs.

Description.	Seely Cove bog, near Pennfield, Charlotte county.				Bogs near Pennfield, Charlotte county.			
	Hunter bog.*		Pocologan bog.*					
Sample No.	1178	1179	1180	1181	1182	1183	1184	
Moisture condition (see note, p. 254)	D	D	D	D	D	D	D	
Loss on air-drying.....%	...	...	...	...	...	...	...
Proximate analysis:								
Moisture .....	%	..	..	..	..	..	..
Ash	%	3.4	13.3	31.6	3.1	2.4	2.3	2.2
Volatile matter	%	64.4	58.9	47.7	66.9	66.8	65.9	66.8
Fixed carbon.....%	%	32.2	27.8	20.7	30.0	30.8	31.8	31.0
Ultimate analysis:								
Carbon .....	%	..	..	..	..	..	..
Hydrogen .....	%	..	..	..	..	..	..
Ash .....	%	..	..	..	..	..	..
Sulphur	%	1.1	1.1	1.1	0.3	0.3	0.3	0.3
Nitrogen	%	1.0	1.4	1.7	1.1	1.1	1.0	1.0
Oxygen .....	%	..	..	..	..	..	..
Calorific value:								
Calories per gram, gross....	5230	4910	4050	5270	5390	5330	5380	
B. Th. U. per lb., gross.....	9420	8840	7290	9490	9710	9600	9690	
Fuel ratio	0.50	0.47	0.43	0.45	0.46	0.48	0.46	
Carbon-Hydrogen ratio.....								
Coking properties								
Location in bog—Sample No. 1183, from depth of over 10 feet; No. 1184, general sample.								
Kind of sample—Prospect.								
Taken by—A. Anrep, Mines Branch.								
Date of sampling—Summer of 1917.								
Remarks—*Bogs traversed by the Canadian Pacific Railway.								

New Brunswick Peat Bogs.

Description.	St. Stephen bog, St. Stephen, Charlotte county				Hayman's bog,		Gitchell Settle- ment- bog
	St. Stephen, Charlotte county		Charlotte county.		St. Stephen,	Charlotte county.	
Sample No.	1187	1188	1189	1190	1185	1186	1191
Moisture condition (see note, p. 254)	D	D	D	D	D	D	D
Loss on air-drying.....%	...	...	...	...	...	...	...
Proximate analysis:							
Moisture .....	%	..	..	..	..	..	..
Ash	%	11.6	5.8	3.4	2.6	6.2	4.9
Volatile matter	%	61.0	64.3	65.4	66.5	61.9	63.1
Fixed carbon	%	27.4	29.9	31.2	30.9	31.9	32.0
Ultimate analysis:							
Carbon .....	%	..	..	..	..	..	..
Hydrogen .....	%	..	..	..	..	..	..
Ash .....	%	..	..	..	..	..	..
Sulphur	%	0.4	0.4	0.4	0.4	0.8	0.8
Nitrogen	%	1.5	1.1	1.5	1.1	1.4	1.4
Oxygen .....	%	..	..	..	..	..	..
Calorific value:							
Calories per gram, gross....	4790	5020	5200	5170	5210	5290	2810
B. Th. U. per lb., gross.....	8620	9030	9360	9310	9380	9520	5050
Fuel ratio	0.45	0.46	0.48	0.47	0.51	0.50	0.39
Carbon-Hydrogen ratio.....							
Coking properties							
Location in bog—Sample No. 1187, depth of 13 feet and over; No. 1188, general sample; No. 1189, depth of 10 feet and more; No. 1190, general sample.							
Kind of sample—Prospect.							
Taken by—A. Anrep, Mines Branch.							
Date of sampling—Summer of 1917.							

Quebec Peat Bogs.

DESCRIPTION.	Peat from Les Bergeronnes, Saguenay county.			Cacouna bog,* near Cacouna,* Temis- couata county.			Lepare bog, near Cacouna, Temis- couata county.			Riviere-du-Loup bog,† Temiscouata county.		
	Sample No.	81	268	207	209	210	211	212	D	D	D	D
Moisture condition (see note, p. 254).....
Loss on air-drying.....	%
Proximate analysis:—												
Moisture	%
Ash	%	3.1	6.0	2.7	2.8	2.1	1.9	2.1	.....	.....	.....	.....
Volatile matter	%	65.7	69.5	69.2	69.3	70.5	69.5	67.8	.....	.....	.....	.....
Fixed carbon	%	25.4	28.3	27.8	28.0	28.6	27.6	28.7	29.4	29.4	29.4	29.4
Ultimate analysis:—												
Carbon	%
Ash	%
Hydrogen	%
Sulphur	%
Nitrogen	%	1.6	0.9	1.0	1.0	0.8	0.9	0.9	0.9	0.9	0.9
Oxygen	%
Calorific value:—												
Calories per gram, gross.....		4,630	5,290	5,000	5,060	5,040	5,000	4,960	5,020	5,020	5,020	5,020
B. Th. U. per lb. gross.....		8,330	9,520	9,600	9,110	9,070	9,000	8,930	9,030	9,030	9,030	9,030
Fuel ratio		0.43	0.43	0.40	0.40	0.41	0.41	0.41	0.41	0.41	0.41	0.41
Carbon-Hydrogen ratio

Kind of sample—No. 268, Prospect.

Taken by—Sample No. 81, private individual; Sample No. 208, A. Anrep, Mines Branch, Ottawa.

Date of sampling—No. 81, 1911; No. 208, Summer of 1912.

*Bog traversed by Canadian Government railway.

†Bog traversed by Temiscouata railway.

Quebec Peat Bogs.

DESCRIPTION.	Riviere-du-Loup bog,* Temiscouata county.							Riviere Ouelle bog,† Kamouraska county.¶
	214	215	216	217	218	219	220	
Sample No.	214	215	216	217	218	219	220	
Moisture con. (see note, p. 254)....	D	D	D	D	D	D	D	
Loss on air-drying.....%	.....	.....	.....	.....	.....	.....	.....
Proximate analysis:—								
Moisture .....	%	.....	.....	.....	.....	.....	.....
Ash	%	2.9	2.3	3.9	4.2	2.8	3.3	3.5
Volatile matter	%	68.8	70.0	67.1	67.2	68.6	67.9	67.6
Fixed carbon	%	28.3	27.7	29.0	28.6	28.6	28.8	28.9
Ultimate analysis:—								
Carbon .....	%	.....	.....	.....	.....	.....	.....
Hydrogen .....	%	.....	.....	.....	.....	.....	.....
Ash .....	%	.....	.....	.....	.....	.....	.....
Sulphur .....	%	.....	.....	.....	.....	.....	.....
Nitrogen	%	1.0	0.9	1.1	1.1	1.0	1.1	1.1
Oxygen .....	%	.....	.....	.....	.....	.....	.....
Calorific value:—								
Calories per gram, gross.....	5,030	4,950	5,100	5,360	4,960	5,050	5,160	
B. Th. U. per lb., gross.....	9,060	8,910	9,180	9,650	8,930	9,080	9,280	
Fuel ratio	0.41	0.40	0.43	0.43	0.42	0.42	0.43	
Carbon-Hydrogen ratio .....	.....	.....	.....	.....	.....	.....	.....

Kind of sample—Prospect.

Taken by A. Anrep, Mines Branch.

Date of sampling—Summer of 1912.

*Bog traversed by Temiscouata railway.

†Bog traversed by Canadian Government railway.

Quebec Peat Bogs.

DESCRIPTION.	Pont Rouge bog, Portneuf county.				Lanoraie bog,* Joliette and Berthier counties		L'Epiphanie, L'Assomption county.¶		
	1177	204	205	106	524	525	526		
Sample No.	1177	204	205	106	524	525	526		
Moisture con. (see note, p. 254)....	D	D	D	D	D	D	D		
Loss on air-drying.....%	.....	.....	.....	.....	.....	.....	.....
Proximate analysis:—									
Moisture .....	%	.....	.....	.....	.....	.....	.....
Ash	%	2.8	9.2	5.4	8.7	5.2	3.5	4.8	
Volatile matter	%	66.7	64.4	66.4	65.0	66.1	67.6	66.9	
Fixed carbon	%	20.5	26.4	28.2	26.3	28.7	28.9	28.3	
Ultimate analysis:—									
Carbon .....	%	.....	.....	.....	.....	.....	.....
Hydrogen .....	%	.....	.....	.....	.....	.....	.....
Ash .....	%	.....	.....	.....	.....	.....	.....
Sulphur	%	0.2	.....	.....	.....	0.1	0.1	0.1	
Nitrogen	%	1.6	2.0	2.2	2.0	1.6	1.6	1.7	
Oxygen .....	%	.....	.....	.....	.....	.....	.....
Calorific value:—									
Calories per gram, gross.....	5,760	4,940	5,120	4,890	5,360	5,390	5,370		
B. Th. U. per lb., gross.....	10,370	8,900	9,220	8,810	9,660	9,710	9,670		
Fuel ratio	0.46	0.41	0.42	0.40	0.44	0.43	0.42		
Carbon-Hydrogen ratio .....	.....	.....	.....	.....	.....	.....	.....

Kind of sample—Prospect.

Taken by A. Anrep, Mines Branch.

Date of sampling—No. 1177, Summer of 1917; Nos. 204, 205, 206, Summer of 1912; Nos. 524, 525, 526, Summer of 1914.

*Bog traversed by Canadian Pacific railway.

Quebec Peat Bogs.

DESCRIPTION.	St. Hyacinthe bog, St. Hyacinthe and Bagot counties.		Canrobert bog, Rouville county.			
	202	263	937	938	939	940
Sample No.	202	263	937	938	939	940
Moisture con. (see note, p. 254)	D	D	D	D	D	D
Loss on air-drying ....	%	.....	.....	.....	.....	.....
Proximate analysis:—						
Moisture ....	%	.....	.....	.....	.....	.....
Ash	%	6.6	5.7	3.0	3.8	4.1
Volatile matter	%	62.9	63.3	68.6	66.6	66.6
Fixed carbon	%	36.5	31.0	28.4	30.2	29.3
Ultimate analysis:—						
Carbon ....	%	.....	.....	.....	.....	.....
Hydrogen ....	%	.....	.....	.....	.....	.....
Ash ....	%	.....	.....	.....	.....	.....
Sulphur ....	%	.....	.....	0.2	0.2	0.2
Nitrogen	%	1.9	1.7	1.6	1.6	1.5
Oxygen ....	%	.....	.....	.....	.....	.....
Calorific value:—						
Calories per gram, gross....	4,890	4,970	5,310	5,340	5,330	5,180
B. Th. U. per lb., gross....	8,800	8,940	9,560	9,620	9,600	9,320
Fuel ratio	0.49	0.49	0.41	0.40	0.44	0.45
Carbon-Hydrogen ratio ....	.....	.....	.....	.....	.....	.....
Kind of sample—Prospect.						
Taken by—A. Anrep, Mines Branch.						
Date of sampling—St. Hyacinthe bog, Summer of 1912; Canrobert bog, Summer of 1916.						

Quebec Peat Bogs.

DESCRIPTION.	Industrial Peat Co., Ltd. Farnham		Farnham bog, Iberville and Missisquoi counties					
	114	929	930	931	932	933	934	935
Sample No.	114	929	930	931	932	933	934	935
Moisture condition (see note, p. 254)	D	D	D	D	D	D	D	D
Loss on air-drying ....	%	.....	.....	.....	.....	.....	.....	.....
Proximate analysis:—								
Moisture ....	%	.....	.....	.....	.....	.....	.....	.....
Ash	%	5.3	4.7	4.6	6.0	4.4	5.2	4.6
Volatile matter	%	65.8	64.7	65.9	63.8	66.1	66.6	67.2
Fixed carbon	%	28.9	30.6	29.5	30.2	29.5	28.2	29.6
Ultimate analysis:—								
Carbon ....	%	.....	.....	.....	.....	.....	.....	.....
Hydrogen ....	%	.....	.....	.....	.....	.....	.....	.....
Ash ....	%	.....	.....	.....	.....	.....	.....	.....
Sulphur ....	%	.....	0.2	0.2	0.2	0.2	0.2	0.2
Nitrogen ....	%	.....	1.7	1.7	1.8	1.7	1.8	1.7
Oxygen ....	%	.....	.....	.....	.....	.....	.....	.....
Calorific value:—								
Calories per gram, gross....	5,430	5,340	5,440	5,350	5,420	5,400	5,540	5,400
B. Th. U. per lb., gross....	9,770	9,626	9,790	9,630	9,760	9,720	9,976	9,730
Fuel ratio	0.44	0.47	0.45	0.47	0.45	0.42	0.42	0.45
Carbon-Hydrogen ratio ....	.....	.....	.....	.....	.....	.....	.....	.....

Kind of sample—Industrial Peat Co., Commercial; Farnham bog, Prospect.
 Taken by—Industrial Peat Co., Operators of bog; Farnham bog, A. Anrep, Mines Branch.

Date of sampling—Industrial Peat Co., 1911; Farnham bog, Summer of 1916.

Quebec Peat Bogs.

DESCRIPTION.	Girard bog, St. Johns county.						
	1176 D	1171 D	1172 D	1173 D	1174 D	1175 D	1176 D
Sample No.	1176	1171	1172	1173	1174	1175	1176
Moisture condition (see note, p. 254)....	D	D	D	D	D	D	D
Loss on air-drying.....%	.....	.....	.....	.....	.....	.....	.....
Proximate analysis:—							
Moisture .....	%	.....	.....	.....	.....	.....	.....
Ash	%	5.2	5.8	6.2	18.6	10.3	9.5
Volatile matter	%	62.6	64.0	61.1	53.9	58.3	61.2
Fixed carbon	%	32.2	30.2	32.7	27.5	31.4	29.3
Ultimate analysis:—							
Carbon .....	%	.....	.....	.....	.....	.....	.....
Hydrogen .....	%	.....	.....	.....	.....	.....	.....
Ash .....	%	.....	.....	.....	.....	.....	.....
Sulphur	%	0.4	0.6	0.6	0.6	0.6	0.6
Nitrogen	%	1.6	1.9	1.8	2.0	1.6	1.6
Oxygen .....	%	.....	.....	.....	.....	.....	.....
Calorific value:—							
Calories per gram, gross.....	5,276	5,280	5,180	4,530	5,050	5,050	5,240
B. Th. U. per lb., gross.....	9,480	9,500	9,330	8,150	9,090	9,090	9,430
Fuel ratio .....	.....	0.51	0.47	0.53	0.51	0.54	0.48
Carbon-Hydrogen ratio .....	.....	.....	.....	.....	.....	.....	.....

Kind of sample—Prospect.

Taken by—A. Anrep, Mines Branch.

Date of sampling—Summer of 1917.

Quebec Peat Bogs.

DESCRIPTION.	Napierville bog, Napierville county.		St Isadore bog, Holton bog,* La Prairie, Chateauguay, Chateauguay Napierville and Napierville and Huntingdon counties.		Large Tea Field bog, near Huntingdon, Huntingdon county.		Small Tea Field bog, near Huntingdon, Huntingdon county.			
	Sample No.	941 D	942 D	943 D	528 D	527 D	198 D	199 D	260 D	201 D
Moisture condition (see note, p. 254)										
Loss on air-drying										
Proximate analysis:—										
Moisture	11.4	11.4	3.7	6.3	13.4	5.6	5.0	4.7	8.1	
Ash	61.1	60.1	66.6	61.6	59.3	65.2	65.8	64.9	64.2	
Volatile matter	27.5	28.5	29.7	31.6	27.3	29.2	29.2	30.4	27.7	
Fixed carbon										
Ultimate analysis:—										
Carbon	56	56	56	56	56	56	56	56	56	
Hydrogen	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	
Ash	0.4	0.4	0.4	0.4	0.4	1.2	1.6	2.0	1.7	
Sulphur	2.4	2.1	1.9	2.0	2.5	2.5	2.5	2.5	2.0	
Nitrogen										
Oxygen										
Calorific value:—										
Calories per gram, gross	4,670	4,720	5,210	4,960	4,740	5,100	5,290	4,970	5,310	
B. Th. U. per lb., gross	8,400	8,490	9,380	8,920	8,530	9,290	9,530	8,940	9,550	
Fuel ratio	0.45	0.47	0.45	0.51	0.46	0.45	0.44	0.47	0.43	
Carbon-Hydrogen ratio										

Kind of sample—Prospect.

Taken by—A. Anrep, Mines Branch.

Date of sampling—Nos. 941, 942, 943, Summer of 1916; Nos. 528, 527, Summer of 1914; Nos. 198, 199, 200, 201, Summer of 1912.

Remarks—*Bog traversed by Grand Trunk railway.

Ontario Peat Bogs.

Description.	Government bog, † Alfred, Prescott county.				Moose Creek bog, Stormont county.			
Sample No.	74	562	659	660	661	662	663	
Moisture condition (see note, p. 254)	D	D	D	D	D	D	D	D
Loss on air-drying.....%	...	...	...	...	...	...	...	...
Proximate analysis:								
Moisture	%	6.0	5.4	9.7	10.8	11.9	9.8	9.9
Ash	%	63.1	64.4	60.7	59.6	61.5	60.9	60.7
Volatile matter.....%	36.9	30.2	29.6	29.6	26.6	29.3	29.4	
Ultimate analysis:								
Carbon	%	56.0	55.4	...	...	...	...	...
Hydrogen	%	5.2	5.2	...	...	...	...	...
Ash	%	...	5.4	...	...	...	...	...
Sulphur	%	...	0.2	0.5	0.5	0.5	0.5	0.5
Nitrogen	%	...	1.5	2.0	2.1	2.2	2.0	2.1
Oxygen	%	...	32.3	...	...	...	...	...
Calorific value:								
Calories per gram, gross....	5,250	5,290	4,660	4,660	4,740	4,690	4,700	
B. Th. U. per lb., gross.....	9,460	9,520	8,390	8,390	8,540	8,450	8,460	
Fuel ratio	0.49	0.47	0.49	0.50	0.43	0.48	0.48	
Carbon-Hydrogen ratio.....	10.7	10.7	...	...	...	...	...

Kind of sample—No. 74, commercial; No. 562, commercial; No. 659, prospect.
 Taken by—No. 74, operators of bog; No. 562, operators of bog; A. Anrep, Mines Branch.

Date of sampling—No. 74, season of 1910; laboratory sample, March 17, 1911.
 No. 562, season of 1911; laboratory sample, May 3, 1915. No. 659, summer of 1915.
 Remarks—†Bog traversed by Canadian Pacific railway.

Ontario Peat Bogs.

Description.	Richmond bog,*† Carleton county.				Meath bog, † Renfrew county.		Westmeath bog, † Renfrew county.		
Sample No.	453	454	455	664	655	656	567	658	
Moisture condition (see note, p. 254)	D	D	D	D	D	D	D	D	
Loss on air-drying.....%	...	...	...	...	...	...	...	...	...
Proximate analysis:									
Moisture	%	12.0	11.0	11.2	20.4	9.2	6.8	4.6	9.9
Ash	%	59.9	60.9	60.8	56.9	59.3	62.0	65.5	62.7
Volatile matter.....%	28.1	28.1	28.0	22.7	31.5	31.2	29.9	27.4	
Ultimate analysis:									
Carbon .....	%	...	...	...	...	...	...	...	...
Hydrogen .....	%	...	...	...	...	...	...	...	...
Ash .....	%	...	...	...	...	...	...	...	...
Sulphur	%	...	0.5	...	1.1	0.5	0.5	0.5	0.5
Nitrogen	%	2.0	1.9	2.1	3.0	1.7	1.8	1.4	1.7
Oxygen .....	%	...	...	...	...	...	...	...	...
Calorific value:									
Calories per gram, gross... .	4,860	4,680	4,710	4,420	4,700	5,260	5,270	4,850	
B. Th. U. pr lb., gross.....	8,750	8,440	8,470	7,960	8,470	9,360	9,480	8,730	
Fuel ratio	0.47	0.46	0.46	0.40	0.53	0.50	0.46	0.44	
Carbon-Hydrogen ratio.....	...	...	...	...	...	...	...	...

Kind of sample—Prospect.

Taken by—A. Anrep, Mines Branch.

Date of sampling—†Summer of 1913. †Summer of 1915.

Remarks—*Bog traversed by Canadian Northern railway.

Ontario Peat Bogs.

Description.	Stoco bog *† Hastings county.		Mariposa, Victoria county.		Ontario county.		Manilla* bog, Sunder- ^a near land		Holland bog, near† Bradford Simcoe and York counties.	
Sample No.	456	457	458	446	438	46	47	48		
Moisture condition (see note, p. 254) D	D	D	D	D	D	D	D	D		
Loss on air-drying.....%	...	...	...	...	...	...	...	...
Proximate analysis:—										
Moisture .....	%	...	...	...	...	...	...	...
Ash	%	14.7	15.1	17.6	11.3	11.2	19.3	12.2	13.6	
Volatile matter.....%	%	61.1	61.6	60.2	59.9	60.5	59.5	63.2	63.4	
Fixed carbon	%	24.2	23.0	22.2	28.8	28.3	21.2	24.6	23.0	
Ultimate analysis:—										
Carbon .....	%	...	...	...	...	...	...	...
Hydrogen .....	%	...	...	...	...	...	...	...
Ash .....	%	...	...	...	...	...	...	...
Sulphur	%	...	1.3	...	0.6	0.6	...	...
Nitrogen	%	2.2	2.2	2.7	2.1	2.0	...	2.4	...	
Oxygen .....	%	...	...	...	...	...	...	...
Calorific value:—										
Calories per gram, gross...		4,390	4,360	4,340	4,500	4,600	4,230	4,640	4,490	
B. Th. U. pr lb., gross....		7,910	7,750	7,810	8,100	8,280	7,610	8,350	8,086	
Fuel ratio		0.40	0.27	0.37	0.48	0.47	0.36	0.39	0.36	
Carbon-Hydrogen ratio.....		...	...	...	...	...	...	...	...

Kind of sample—Prospect.

Taken by—A. Anrep, Mines Branch.

Date of sampling—Summer of 1913. †Summer of 1910.

Remarks—†Bog traversed by Canadian Northern railway.

Ontario Peat Bogs.

Description.	Holland bog, near Bradford, Simeoe and York counties.			
Sample No.	49	50	51	52
Moisture condition (see note, p. 254) D	D	D	D	D
Loss on air-drying.....%	...	...	...	...
Proximate analysis:—				
Moisture .....	%	...	...	...
Ash	%	12.2	17.3	15.2
Volatile matter.....%	%	64.3	59.6	64.6
Fixed carbon	%	23.5	23.1	20.2
Ultimate analysis:—				
Carbon .....	%	...	...	...
Hydrogen .....	%	...	...	...
Ash .....	%	...	...	...
Sulphur .....	%	...	...	...
Nitrogen	%	2.5	...	...
Oxygen .....	%	...	...	...
Calorific value:—				
Calories per gram, gross...		4,660	4,330	4,410
B. Th. U. pr lb., gross....		8,390	7,790	7,950
Fuel ratio		0.37	0.39	0.31
Carbon-Hydrogen ratio.....		0.36	0.41	0.38

Kind of sample—Prospect.

Taken by—A. Anrep, Mines Branch.

Date of sampling—Summer of 1910.

Ontario Peat Bogs.

Description.

	Marsh Hill bog, Ontario county.					
Sample No.	459	460	461	462	463	465
Moisture condition (see note, p. 254)	1)	D	D	D	D	D
Loss on air-drying%	...%	...%	...%	...%	...%
Proximate analysis:—						
Moisture	11.1	10.2	11.5	10.9	11.0	10.8
Ash	61.0	61.5	61.1	61.6	60.0	61.8
Volatile matter	27.9	28.3	27.4	27.5	29.0	27.1
Fixed carbon						
Ultimate analysis:—						
Carbon						
Hydrogen						
Ash						
Sulphur						
Nitrogen						
Oxygen						
Calorific value:—						
Calories per gram, gross.	4,590	4,580	4,430	4,530	4,560	4,540
B.Th.U. per lb., gross	8.270	8.240	7.980	8.150	8.200	8.180
Fuel ratio	0.46	0.46	0.45	0.45	0.44	0.44
Carbon-Hydrogen ratio . . . . .	...	...	...	...	...	...

Kind of sample—Prospect.

Taken by—A, Anrep, Mines Branch.

Date of sampling—Summer of 1913.

Remarks—Bog traversed by Grand Trunk railway.

Ontario Peat Bogs.

Description.	Amaranth* bog, near Crambie, Dufferin county.	Luther bog, near Grand* Valley Dufferin and Wellington counties.	West-* over bog Wentworth county.	Cargill* bog, Brue county.	Fort† Frances bog, Bainbridge river county.
Sample No.	419	450	451	452	444
Moisture condition (see note, p. 254)	D	D	D	D	D
Loss on air-drying.....%	... .	... .	... .	... .	... .
Proximate analysis:—					
Moisture	65	77	70.9	18.8	8.7
Ash	12.9	67.2	56.8	55.6	62.4
Volatile matter	59.9	27.2	24.4	24.1	28.3
Fixed carbon .....	...	...	...	...	...
Ultimate analysis:—					
Carbon	55	55	55	55	55
Hydrogen	6.3	6.3	6.7	6.3	6.5
Ash	1.7	0.8	2.4	2.3	2.1
Sulphur .....	...	...	...	...	...
Nitrogen .....	...	...	...	...	...
Oxygen .....	...	...	...	...	...
Calorific value:—					
Calories per gram, gross	4,840	5,200	4,550	4,180	4,110
B.Th. U. per lb., gross	8.710	9.360	8.200	7.920	7.460
Fuel ratio	0.45	0.45	0.46	0.43	0.43
Carbon-Hydrogen ratio .....	...	...	...	...	...

Kind of sample—Prospect
Taken by—A. Anrep, Mines Branch.
Date of sampling—*Summer of 1913. †Summer of 1911.

Ontario Peat Bogs.

DESCRIPTION.	Samples from bogs on T. & N. O. Ry., South of Cochrane.									
	No. 1 bog, mileage 249.			No. 2 bog, mileage 240.			No. 3 bog, mileage 243.			
	1085	1086	1087	1088	1089	1090	1091	1092	1093	
Sample No.	1085	1086	1087	1088	1089	1090	1091	1092	1093	
Moisture condition (see note, p. 254).....	D	D	D	D	D	D	D	D	D	
Loss on air-drying % .....	....	....	....	....	....	....	....	....	....
Proximate analysis:—										
Moisture ..... %	....	....	....	....	....	....	....	....	....
Ash ..... %	....	....	....	....	....	....	....	....	....
Volatile matter ..... %	....	....	....	....	....	....	....	....	....
Fixed carbon ..... %	....	....	....	....	....	....	....	....	....
Ultimate analysis:—										
Carbon ..... %	....	....	....	....	....	....	....	....	....
Hydrogen ..... %	....	....	....	....	....	....	....	....	....
Ash ..... %	....	....	....	....	....	....	....	....	....
Sulphur ..... %	....	....	....	....	....	....	....	....	....
Nitrogen ..... %	....	....	....	....	....	....	....	....	....
Oxygen ..... %	....	....	....	....	....	....	....	....	....
Calorific value:—										
Calories per gm., gross	5,290	5,130	5,190	4,970	5,140	4,720	4,650	5,090	4,880	
B. Th. U., per lb., gross.	9,530	9,240	9,340	8,950	9,250	8,500	8,380	9,170	8,790	
Fuel ratio .....	....	....	....	....	....	....	....	....	....
Carbo-Hydrogen ratio...	....	....	....	....	....	....	....	....	....
Location in bog—depth in feet	6	7	9	14	2	4	6	3	6	

Taken by—A. A. Cole, Chief Engineer, T. & N. O. Ry.

Date of sampling—Summer of 1917.

Remarks—These samples contained 85% to 90% of water when received.

Manitoba Peat Bogs.

DESCRIPTION:		Litter Bog,* 2 miles from Point Dubois, Secs. 33-34, Tp. 15, R. 14, E. of principal meridian	Mud Lake Bog,* 3 miles from Point Dubois, Secs. 28 & 33, Tp. 15, R. 14 E. of principal meridian	Rice Lake Bog,* $\frac{7}{12}$ miles from Point Dubois, Secs. 25-26, Tp. 15, R. 13 E. of principal meridian	Boggy Creek Bog,* $\frac{12}{12}$ miles from Point Dubois, Secs. 29-32, Tp. 15, R. 13 E. of principal meridian
Sample No.	134	139	147	148	135
Moisture condition (see note, p. 254)	D	D	D	D	D
Loss on air-drying .....	....	....	....	....	....
Proximate analysis:—					
Moisture	7.7	7.7	56.1	31.8	28.6
Ash	66.1	69.1	34.8	51.1	65.0
Volatile matter	26.2	23.2	9.1	17.1	18.4
Fixed carbon					
Ultimate analysis:—					
Carbon .....	.....	.....	.....	.....	.....
Hydrogen .....	.....	.....	.....	.....	.....
Ash .....	.....	.....	.....	.....	.....
Sulphur	0.2	.....	.....	.....	.....
Nitrogen	1.6	1.5	2.4	.....	2.3
Oxygen .....	.....	.....	.....	.....	.....
Calorific value:—					
Calories per gram, gross	5,050	4,870	.....	4,850	.....
B. Th. U. per lb., gross	9,090	8,760	.....	8,730	.....
Fuel ratio	0.40	0.34	0.26	0.33	0.35
Carbon-Hydrogen ratio .....	.....	.....	.....	.....	.....
Coking properties .....	.....	.....	.....	.....	.....
Hoffman potash test .....	....	....	....	....	....

Kind of sample—All prospect.

Taken by—All by A. Annep, Mines Branch, Ottawa.

Date of sampling—During summer of 1911.

*Bog traversed by City of Winnipeg Construction railway.

Manitoba Peat Bogs.

DESCRIPTION.

	Transmission Bog, ^a 18 miles from Point Dubois, Secs. 19-21, 28-30, T.p. 15, R. 12 E. of principal meridian.	Whitemouth Bog, ^b Whitemouth, Tps. 4-13, Ranges 11-14 E. of principal meridian.	Lac du Bonnet Bog, ^c near Lac du Bonnet, Sec. 2, T.p. 15, R. 10 E. of principal W. of principal meridian.
Sample No.	146	142	468
Moisture condition (see note, p. 254)	D	D	145
Loss on air-drying . . . . .	. . . . .	. . . . .	D
Proximate analysis:—			. . . . .
Moisture . . . . .	%	%	. . . . .
Ash . . . . .	%	%	. . . . .
Volatile matter . . . . .	%	%	. . . . .
Fixed carbon . . . . .	%	%	. . . . .
Ultimate analysis:—			. . . . .
Carbon . . . . .	%	%	. . . . .
Hydrogen . . . . .	%	%	. . . . .
Ash . . . . .	%	%	. . . . .
Sulphur . . . . .	%	%	. . . . .
Nitrogen . . . . .	%	%	. . . . .
Oxygen . . . . .	%	%	. . . . .
Calorific value:—			. . . . .
Calories per gram, gross . . . . .	. . . . .	. . . . .	. . . . .
Fuel. Th. U. per lb., gross . . . . .	. . . . .	. . . . .	. . . . .
Fuel ratio . . . . .	. . . . .	. . . . .	. . . . .
Carbon-Hydrogen ratio . . . . .	. . . . .	. . . . .	. . . . .
Coking properties . . . . .	. . . . .	. . . . .	. . . . .
Hoffman potash test . . . . .	. . . . .	. . . . .	. . . . .

Kind of sample—All prospect.

Taken by—All by A. Anrep, Mines Branch, Ottawa.

Date of sampling—During summer of 1911.

*Bog traversed by City of Winnipeg Construction railway.

†Bog traversed by Canadian Pacific railway.

SULPHITE PEAT COAL.

At the annual meeting of the Swedish Chemical Society and the Swedish Society of Paper and Cellulose Engineers, at Sundsvall, Sweden, in 1917, an address was given by R. W. Strehlenert who had carried out a whole lot of work in preparing coal from the residues of the paper sulphite process which he had termed sulphite coal. These experiments were carried out at the Gota Sulphite Mills at Gota, Sweden. His results were such that he was induced to experiment with peat as is described below.*

Mother Lye from the Decomposition of Sulphite Lye as Hydrolyzing Liquor for Peat.

Previous experiments and experiences gave me reason to work in the reverse direction, that is, to aim to make the Peat more easily de-watered by heating it with Mother Lyes from Sulphite Coal.

As known, the so-called "wet carbonizing" method consists of the Peat being subjected to an hydrolysis which bursts the cell fabric, thereby changing the substance from fibrous to crystallinic. The term "wet carbonizing" is a misnomer, inasmuch as carbonization of the Peat cannot very well take place at the temperature which is used, or about 180°C. It is only a common hydrolysis.

The Cellulose is very easily hydrolyzed in the presence of smaller amounts of inorganic or organic acids. The Humus Acid in the Peat is ordinarily sufficient for the hydrolysis of the Peat if this is carried out under pressure and at a temperature of 120 to 180°C.

If an extra amount of Acid is now added, for instance, a mineral acid, the hydrolysis takes place still easier. The Mother Lye contains, as I have previously shown, a total amount of about 0.35% of Sulphuric Acid, of which about 0.02% is free acid. This small amount of acid is sufficient for the hydrolysis of the Peat at a temperature of 140°C, and at a pressure of about 5 to 8 kg. per square centimeter. In de-watering the product after the heating, the Peat water, which is mixed with the Mother Lye, may be re-used for a new hydrolysis of Peat, and experiments have shown that with advantage the liquor can be re-used four times.

As might be expected, the dry substance in the Mother Lye is precipitated with the Peat, and I have thereby found

* Reprint from Pulp and Paper Magazine of Canada, 1918—vol. 16, p. 735.

a means to utilize all the organic substances in the Sulphite Lye.

The Influence of the Hydrolysis in De-Watering the Peat.

The Peat which I used for the experiments has been ordinary wet Peat with a dry substance of about 8%, and thus containing about 92% of water. Previous to the hydrolysis I removed as much water as possible in a centrifugal separator, and thereby have been able to raise the amount of dry substance to about 12%, that is, an amount which corresponds to peat which is dug from a drained Peat bog. After hydrolysis with the Mother Lye during twenty minutes at 140°C. and 6 kg. pressure per square centimeter, I have, in the same centrifugal separator, and with the same speed, de-watered the product, thereby obtaining about 25% dry. This product has thereafter been easily pressed about 50 to 55% dry. After drying it has been easily disintegrated into an amorphous powder. Microscopically examined after hydrolysis the Peat shows no trace of cells, except some coarse fibres and roots which, naturally, exist always in the Peat, and which are only partly affected by the reaction. The advantages found in this form of so-called "wet carbonizing" of Peat consist in a reduced temperature during the hydrolysis and saving the fuel through the mother Lye being received from the Sulphite Coal factory at about 100°C.

In order to show the influence of the hydrolysis on the Peat when using mother Lye from the Sulphite Coal, I have carried out four consecutive so-called "Peat Cooks." and therein used the same mother Lye. The different stages of the hydrolysis may be found by ascertaining the amount of sugar in Lyes contained at the commencement of the first cook 8.5% of dry substance, and of Sulphuric Acid 0.35% total, of which 0.02% formed free acid. There was hardly any trace of sugar.

		Dry Substance in Mother Lye	Sugar in Mother Lye	H ₂ SO ₄ in Mother Lye
After First	Peat Cook	3.9%	0.42%	0.42%
After Second	Peat Cook	2.4%	0.32%	0.58%
After Third	Peat Cook	1.7%	0.17%	0.96%
After Fourth	Peat Cook	1.3%	0.09%	0.11%

From these experiments it may be seen how far the re-use of the same mother Lye may be carried out. Two, or at most, three times ought to be sufficient, as the dry substance in the mother Lye thereby has been reduced to such an extent

that it corresponds to the amount of food in the Peat water after an analogical hydrolysis without extra addition of an acid. From the Table it may be seen that the formation of sugar decreases considerably after the second cook. This is partly caused by the fact that the Lye after each cook is diluted with more Peat water, and that the amount of Sulphuric Acid decreases.

In order to ascertain the influence of the process on the Peat at various temperatures and pressures I have carried out a series of experiments up to 200°C. and 20 kg. pressure. I have thereby carried out analogical de-watering experiments with those described above, and I have not obtained any better results. Should, on the other hand, the mother Lye contain a trace of additional free acid the result is visibly improved and the process may in such case be carried out at a lower temperature than 140°C. It has also been found that if the heating or hydrolysis takes place at a high temperature, the product decreases in weight. All the experiments have been carried out in an autoclave wherein I forced air so that the pressure has been higher than the corresponding evaporation pressure of steam in order to prevent boiling. The reduction of weight of the Peat product treated at the higher temperature is likely caused by partial formation of Carbon Dioxide. Probably also secondary reactions take place at the high temperature. I have as yet not had time to study these conditions thoroughly, but they are probably connected with the heating value of the product at the various treatments. Samples of the so-called "wet carbonised" Peat which are available to me from the Larson & Ekenberg's method show 6,200 calories after an hydrolysis at 180°C. and 8 kg. pressure. I have not tested, myself, for heating value, any other product than what I obtained after an hydrolysis at 120 to 140°C.; the heating value in this case has been 5260 calories with a moisture of 6.4% and 3.6% of ashes.

Without doubt, the lower temperature is to be preferred during the hydrolysis, inasmuch as thereby there is no loss in material, which certainly will counter-balance the higher heating value of the fuel from a treatment at a higher temperature. The prime factor in this method is the large saving of heat. In carrying out the hydrolysis as I have described above, I have always obtained a larger weight of coal after the hydrolysis than corresponds to the amount of peat substance whereby the 25% of the dry substance in the mother lye is precipitated with the peat.

Yield of Peat Fuel Compared with Sulphite Coal Simultaneously Obtained.

In decomposing sulphite lye when using autoclaves of 10 cubic meters total volume, and filled with 7.5 cubic meters of lye, the yield of mother lye from each precipitation is, on an average, 4.2 cubic meters.

Based on a yield of 950 kg. of sulphite coal per autoclave we thus obtain 4,400 liters of mother lye for each ton of coal.

At the hydrolysis of the peat I have used mother lye in comparison with 12% peat substance at 600 to 700; from this follows that per ton sulphite coal obtained 616 kg. of peat substance (estimated as dry) are obtained. If the mother lye is used twice, as should be done for making the process effective, $2 \times 616 = 1,232$ kg. of peat substance is obtained: To this is to be added the substance which remains in the mother lye from the sulphite coal precipitation, and which constitutes 25% of the total substance in the sulphite liquor, or 318 kg.

In producing 1 ton of sulphite coal, 1,550 kg. of peat coal are thus also obtained. A great advantage is that this combination is only partly affected by the efficiency of the sulphite coal factory, inasmuch as losses during the first process are recovered in the second, and this within a limit of about 5 or 6%. Should the mother lye contain too much dry substance this cannot be fully precipitated in two consecutive cooks. The percentage of dry substance, or 8½%, which I stated as existing during the experiments may be regarded as a maximum; generally the percentage is 5 or 6%.

Method for Hydrolysis of Peat.

As known, the present methods worked out for the so-called "wet carbonizing" system consist of treating the peat in continuously working apparatus. As far as known to me, this form of treatment has never proved satisfactory. As in that process the heat required is of great importance, it is easily understood how difficult it is to arrange the apparatus for obtaining a satisfactory and economical result.

In placing my suggestions before you I wish to say that the process is carried out analogically with that one used for the manufacture of sulphite coal, that is, the hydrolysis of the peat is carried out in autoclaves which, on account of the low pressure which is required for the heating, may be considerably larger.

These latter are filled with peat substances and mother

lye is then drawn from the autoclaves in the sulphite coal factory, and finally air is admitted. For the peat two or three large autoclaves are used, and the generated warm steam and gases are blown from one to another of the autoclaves in turn as these are ready to be discharged. During my experiments it was shown that a considerable portion of organic acid is carried away with the gases. If this acid is carried from one autoclave to another an advantage is gained in the effect of the operation, and thereby time and heat are saved during the process. The heating of large peat autoclaves is economically accomplished by a combination of direct and indirect steam.

The Heat Required for Producing One Ton of Peat (Calculated as Dry.)

In correspondence with the above stated figures 7.14 cubic meters of mother lye are required for producing one ton of dry peat. This mother lye contains about 500 kg. of dry substance. In obtaining 1 ton of peat also 250 kg. of substance are obtained from the mother lye during two consecutive cooks; that is, in case the mother lye is not thoroughly precipitated previously; Thus, in all 1,250 kg. are obtained.

If the maximum temperature during the hydrolysis is assumed to be 140°C. and the mother lye in favorable cases is 100°C., and the peat substance 15°C.; and if, further, the heat is utilized in an economical way from one autoclave to another, the amount of heat required for complete hydrolysis is about 1,200,000 calories.

1,250 kg. of peat coal are then obtained from the autoclave. If the fuel value of this is 5,260 calories, the total amount is thus 6,575,000 calories; that is, the consumed heat for the process is about 20% of the product.

The above stated figures are, naturally, only given to convey the idea of this combination and the results that may be gained from same. For the de-watering of the peat product after hydrolysis plans are also worked out, but these can only be published later on, as the experimental apparatus is not yet ready.

The Amount of Fuel Which May Be Recovered from the Swedish Sulphite Cellulose Industry Should the Alternative Now Related Come Into Use.

The Swedish sulphite industry embraces at present a yearly production of about 900,000 metric tons of cellulose. In case the sulphite coal manufacture should be carried out

at all the Swedish mills, 667,500 tons of fuel would be obtained per annum, provided the method be worked under favorable conditions.

If this method is combined with the last one described, an additional 1,034,625 tons of peat coal would be obtained, or a total of about 1,700,000 tons of coal. The last figures are merely given for the sake of general interest. The last-mentioned alternative is, naturally, dependent on the proximity of suitable peat bogs to the sulphite mill, but is stated in order to show in what way the waste product may be suitably utilized should analogical conditions be favorable; and this in particular times when the fuel question belongs to the order of the day.

The directions I have given regarding combination may likely be of a certain interest, and the peat should undoubtedly be of great importance when used direct for manufacture of sulphite coal; and this in particular when small quantities increase the yield in a large proportion. Therefore every sulphite mill that is able to obtain peat may thereby, in a simple way, largely increase the yield of the sulphite coal factory.

NOTE—The following figures are equivalents for figures used in this article.

1 Metric Ton = 2,204.6 lbs.

1 Kilogram = 2.2 lbs.

1 Litre = 0.264 U.S.A. Gallons.

1 kg. per square c.m. = 14.225 lbs. per sq. inch.

CANADIAN PEAT COMMITTEE REPORTS PROGRESS.*

Progress is being made by the Peat Committee of Canada,—but no peat. Unfortunately this committee was appointed too late to be a factor in the coming winter's fuel supply for Ontario. Moreover, if the present limited plans are followed, this committee will not be a factor in the fuel supply for the winter of 1919-20. It will be the winter of 1920-21 before any considerable quantity of peat is on the market, and by that time public interest in the enterprise may be thoroughly chilled.

The Dominion government owns a large peat bog at Alfred, Ont., where exhaustive experiments were conducted some years ago and about 3,000 tons of standard peat fuel were manufactured and sold to householders in Ottawa and neighboring municipalities. The bog was then turned over

* Reprint of Editorial—The Canadian Engineer, 1918—vol. 35, p. 213.

to a private company for further development, but the company spent all of its money in getting ready to operate and had no capital left to carry on the enterprise; its plant was junked.

"The results of the manufacturing operations conducted at Alfred indicate that with strict business management, peat could be manufactured at \$1.70 per ton in the field. This figure includes all charges such as interest on investment, amortization, etc.," writes B. F. Haanel, who is one of the four members of the Peat Committee of Canada. In view of this fact, should not either the Dominion government or the Ontario government have adopted more vigorous measures to manufacture peat fuel during the present summer?

The Peat Committee is doing very good work, as good work as can be done under the limited program laid down by the two governments, but the question arises as to whether or not that program is inadequate to meet the needs of the situation.

Not more than 120 sun-drying days per annum can be depended upon in Ontario in the manufacture of peat, and the last of those days of this calendar year are slipping by with no prospect of any peat being laid out to dry.

When the committee was appointed last spring, their first task was to design a modern machine. Ernest V. Moore, of Montreal, was engaged as consulting engineer to design two plants. One of these will be very similar to the one he built at Alfred, but re-designed in the light of the experience there obtained. The other is an entirely new design, which, if successful, will no doubt prove a distinct step forward in the manufacture of machine peat fuel. It is a device that will excavate the peat, lay it out to dry, do the necessary marking into cubes and, when the peat is dry, harvest it into a pile. "The one piece of apparatus will do all this work," says Mr. Moore, "and it will be more simple and less costly per ton of output than any peat plant known to date."

After these plants were designed, manufacturing arrangements were made by the committee. The factory of the William Hamilton Co., at Peterborough, Ont., is being largely devoted at present to the requirements of the committee. The two plants will cost about \$45,000, but neither of them is likely to be ready for extensive operation this year. It is expected that the two plants will produce a minimum of 20,000 tons next year, and the present program does not call for any additional plants to be put into operation.

As the fuel value of peat, compared with the average

available anthracite, is as 1:1 8/10, 20,000 tons of peat will replace less than 12,000 tons of anthracite coal during the winter of 1919-20. The governments' present idea is to see whether this 20,000 tons of peat, manufactured at Alfred under commercial conditions, can be sold through ordinary dealer channels, or by some other entirely commercial means, so as to compete satisfactorily with other fuels. If the new peat plant is demonstrated to be a commercial success (the government experts have no doubt about its success from a manufacturing standpoint), the governments do not intend to go into the peat business. They intend to leave it to private individuals who own peat bogs throughout Ontario, and who, aided by the official balance sheet in regard to those 20,000 experimental tons, may be able to secure capital to develop their bogs as private enterprises.

Assuming that the experimental sales made in the winter of 1919-20 are commercially successful, it is quite doubtful whether private financial arrangements, and the manufacture of additional plants for private companies, can be carried out with sufficient rapidity to enable those private companies to make any considerable amount of peat fuel even for the winter of 1920-21.

Peat appears to be a most desirable fuel from every standpoint excepting its bulk, and with the present fuel scarcity, no one is likely to complain about that. Its calorific value is about 7,000 B.t.u's as compared with 12,500 for anthracite (or probably 10,000 for the average anthracite received in Canada last year). There is no clinker from peat, it ignites very readily, and its ash is very fine.

Raw peat contains 88% water, and as the material is of a colloidal nature, not one-sixth of the water can be pressed out; yet in some way the moisture content must be reduced to about 25%. Peat may be dried by heat, but to do this more fuel is required than would be supplied by the manufactured peat. Solar energy is the only known form of energy that is cheap enough to be economical in the manufacture of peat, therefore the material has to be laid out in the sun to dry after it has been excavated from the bog, and it requires about thirty drying days.

The new plant which the Peat Committee is manufacturing is apparently a model one, including bucket excavators, a very efficient macerator, conveyors for laying the material on the field, spreaders, markers, and mechanical harvesters. An industrial railroad system will grid-iron the bog and little cars will carry the material to the railroad. The whole plant

has been admirably arranged and the able chairman of the committee, Arthur A. Cole, of Cobalt, Ont., is to be congratulated upon his work.

Mr. Cole has been well assisted by the other members of the committee: B. F. Haanel, of Ottawa; R. A. Ross, of Montreal; and R. C. Harris, of Toronto. Mr. Cole and Mr. Harris represent the Province of Ontario, and Mr. Ross and Mr. Haanel represent the Dominion Government. Mr. Haanel is secretary of the committee.

The powers and duties of the committee should be much extended. The government might be able to expropriate other peat bogs, if necessary, or to make some arrangement for their use upon a royalty basis, and if enough additional plants could be manufactured in time, peat could be made a real factor in the fuel situation during the winter of 1919-20 at least.

It is understood that the Peat Committee of Canada has prepared a statement reporting progress and relating its plans for next year. Undoubtedly this statement has been submitted to Hon. G. Howard Ferguson, Ontario Minister of Lands, Forests and Mines; and to Hon. Martin Burrell, Dominion Minister of Mines. The statement should be issued to the press. If the people were to realize that a huge quantity of most desirable fuel exists within the borders of Ontario, popular opinion might support the government in taking any steps necessary to develop that fuel in the wholesale manner required by present and prospective exigencies.

PEAT AS A FUEL.

Peat is disintegrated and partially decomposed vegetable matter—vegetable mud. It collects in and fills up swamps under favorable conditions. Vast deposits of it are known in temperate and cold climates. It is not found in warm localities, for there the decay of vegetable matter is too rapid. The formation of peat illustrates the conditions under which coal originates. The rate of growth of a peat bog is often from one to four inches a year, the depth varying from ten to twenty feet. When dried in the open air peat forms a valuable domestic fuel, and its value is greatly enhanced by compression into small blocks or briquettes, whether alone or in mixture with coal dust. In times and countries where the forests could not supply sufficient fuel, men have turned to peat to take the place of wood for burning. Its greatest importance seems to have been in the eighteenth century,

when the forests of northern Europe had been to a great extent cleared away and the use of coal had not yet become general as it was later to do when transportation facilities were to make distribution practical. At that time peat was used for household purposes by the rural populations of northern Germany, Scandinavia, Russia, France and the British Isles. In Ireland particularly peat was and still continues to be a much-relied-on natural resource. Yet the supply from European bogs, though drawn on for many centuries, seems never to have approached exhaustion, due no doubt to the fact that under favorable conditions accumulations of peat are renewed from two to three feet in the course of thirty or forty years.

Peat was burned to some extent in the United States during Colonial times and even later, until the progressive cheapness of anthracite coal lead to the abandonment of local fuel. But the present generation of Americans does not know the extent of the peat deposits in this country or their value. It has been estimated that there are 15,000,000,000 cubic feet of peat in Massachusetts alone, while the Great Dismal Swamp of Virginia and North Carolina, forty miles long by twenty-five miles wide, is practically an inexhaustible storehouse of the material. Peat is found along the coast of New Jersey and south along the Atlantic coast to the central parts of Florida, and along the Mississippi and other rivers with well-developed inundation plains. There are also deposits west of the Mississippi, but these become more and more scanty as one journeys westward, and are of little economic value. By far the richest deposits of this country lie in New England, east of the Berkshire Hills and Green Mountains. Going inland from the seashore the peat bogs decrease in quality as fuel, but their value as fertilizer increases. The enormous deposits in Canada and the United States have been little used, save in Canada, where compressed peat is a product of the closing decade of the nineteenth century.

Peat has been commercially unsuccessful in the past, due to its bulkiness, which makes it difficult of transportation, and to the cheapness of coal. By various devices, however, there can be produced from this vegetable mud a compact material fairly comparable in quality with lignite or the poorer bituminous coals. Charcoal made from compressed peat is superior to wood charcoal and even compares favorably with coke. That obtained from the uncompressed peat is used to temper cutlery, etc., and as a deodorizer and anti-septic. In agriculture, too, peat is important, for three rea-

sons,—it makes good fertilizer, is valuable as an absorbent material when mingled with refuse, and helps to retain moisture when mixed with dry, sandy soils.—(Public Information Committee of the American Museum of Natural History.)

PEAT FOR FUEL IN GREAT BRITAIN.

The controller of coal mines has issued a circular in which he directs attention to the importance of developing the resources of any alternative kinds of fuel, in view of the drastic economy in the use of coal which is necessitated by the release of miners for service in the Army and the increasing demands of our Allies. He urges that the matter should be taken up by the local coal committees where they exist, and local authorities generally, pointing out that hitherto the great resources of the United Kingdom have not been developed to any extent, and that the needs of the time render it imperative that the fullest use should be made of the available supplies. There are larger supplies of peat in the country than is generally thought, but the controller states that if peat-cutting is to be done on any considerable scale, so that the fuel may be of use in the forthcoming winter, operations will have to be started immediately, as the peat-cutting season, which begins in some districts early in March, is already far advanced. Peat which is not cut by the end of July is not likely to be in a fit condition for use during the winter. In the circular directions are given in the method of cutting, drying and preparing peat for fuel.—(The Colliery Guardian, 1918, Vol. 106, p. 87.)

PEAT AND WOOD FOR GAS MAKING IN ITALY.

At the end of 1917 the Italian Fuel Controller issued an order to the effect that the use of coal for gas making was to be prohibited, and works were to be allowed to use only wood, lignite, peat and the like. The order has been severely criticised on the ground of its extravagance by Pacchioni and Bohm, two Italian members of the Societe Technique du Gaz. They point out that the acid nature of the liquors produced by the distillation of materials of a woody nature results in corrosion of plant which is designed for dealing with alkaline liquors. The yield of gas is small and its quality very poor. The temperature at which it is necessary to distill, in order to obtain an adequate yield of gas, is destructive to the very substances which in the ordinary way are profitably re-

covered in the distillation of wood. The residual coke or charcoal is of a light, porous nature and of doubtful value. It is suggested that these drawbacks could be avoided by distilling mixtures of these substances with at least 35 to 40 per cent coal. The importance is urged of the rational utilization of fuels by distillation instead of burning directly in furnaces of primitive type. They conclude that there is good ground for the declaration that, failing a supply of coal in the minimum proportion of 35 to 40 per cent, it would be in the national interest to suspend the operation of the gas works.
—*Jour. Soc. Chem. Ind.*, 1918, V. 37, p. 248.)

PEAT AS A FUEL IN SWITZERLAND.

In a paper read before the Societe Vaudoise des Sciences Naturelles, B. Laurent gave an account of the natural formation of peat. The peat is dug with a special tool having two cutting edges at right angles. There are also machines in use for the purpose, which the author describes, such as the Anrep-Svedala type, of Swedish origin, and the Dolberg and Wielandt type, of German origin. He then describes various methods of briquetting and drying. The present price of coal of a calorific value of about 13,000 B.t.u., delivered at Lausanne, is \$19.75 per ton. Assuming that the peat has a calorific value of about 6,100 B.t.u. and for various reasons, such as difficulty in transport and in use, that two thermal units in peat are only equal in practice to one unit in coal, then the corresponding value of peat should be \$4.65 per ton, while the actual prices are said to be higher than this figure.

EXTRACTING KAURI GUM OIL FROM PEAT IN NEW ZEALAND.

The process of extracting crude oil together with the by-products, acetic acid, ammonia, pitch, and gum spirit, from kauri peat gum swamps, is progressing in New Zealand, and according to reports there seems to be an almost unlimited source of supply, since it is reported one company has the rights covering 40,000 acres of these old swamp lands, and this is only a small portion of the total field.

It is stated the yield of crude oil ranges from 76 gallons per ton from the gum dirt to 168 gallons per ton from gummy timber. As yet no large quantities of the crude oil have been refined, and its actual commercial value has not been definitely

established, but it is estimated that the business may become a profitable industry.—(Consular Report.)

GAS FROM WOOD AND PEAT IN SWITZERLAND.

The great shortage of coal in Switzerland is leading to the distillation of a very considerable tonnage of wood and peat for gas making. In order to remove much of the carbon dioxide in the gas produced by such distillation, a process suggested by M. Demolis is now being developed. The process consists in passing the raw gas over incandescent wood charcoal; the carbon dioxide being thus converted into carbon monoxide, while the acetic acid present in the gas is decomposed. A better wood tar is also said to be obtained. The process is in actual use in works possessing vertical retorts. Swiss gas makers are seeking to organize means for the cutting of timber for gas making and for the working of peat deposits. In some cases it is proposed to enrich the gas with acetylene.—(Gas J., June, 1918.)

THE CARBONIZATION AND DISTILLATION OF PEAT.

Messrs. C. Galaine and C. Houlbert recently submitted a paper to the Paris Academie des Sciences on the carbonization and distillation of peat, sawdust, household refuse and other light organic products.

The value of peat lies in the direction of distillation rather than combustion, and on these lines it could supersede wood in the production of acetic acid, methylated spirit, ammonia and tar, the basis of so many dyes.

In the process of distillation, peat, being a light material, requires larger retorts than coal, and of a design which facilitates the transmission of heat from the surface toward the center. Experiments have shown that revolving retorts produce the best results. The apparatus devised and described by the authors is on the principle of the roasting appliances used for coffee, chicory, etc., but, of course, with the addition of a receiver for collecting the distilled vapor, the great object being to provide an apparatus complete in itself for continuous and all-round operation.

This apparatus consists of six cylindrical retorts, each mounted on its own axis and capable of uniform rotation, whilst the individual cylinders are arranged in radial relation to a rotary central pivot, so that the retorts charged

with peat can be entered into and withdrawn from a stationary semi-circular furnace in succession.

When the apparatus is in operation there are always three retorts undergoing distillation in the furnace, the other three being outside, one condensing, another emptying and the third re-charging. The distillation takes on an average about 40 minutes for retorts holding a ton of peat, and making six revolutions per minute.

To enable the gas arising from the carbonized peat to pass out of the retorts, the hollow shaft of each is perforated so as to provide a passage from the inside of the retort to a collecting chamber in the axis of the pivot and thence to the stills for fractional distillations.

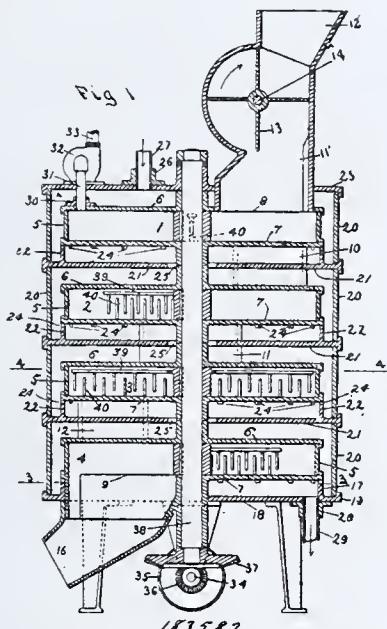
The rotary movement of the retorts insures rapid transmission of heat from the furnace, and as this heat acts on a very large surface, the peat is uniformly carbonized in a short time at a relatively low temperature, a result which, it is claimed, is impossible to obtain by any other process.—(Through Colliery Guardian.)

Carbonized Peat Blocks. (W. Anderson, Br. P. 114,371, Nov. 24, 1917.) Wet peat, 100 parts, and ground coal tar pitch, 20 parts, are mixed together and passed through a pulping machine, and then formed into blocks. The blocks are dried in a stove in a current of hot air, and are then suitable for carbonization in a retort.

Wet Carbonizing. (W. H. Boorne, Br. P. 114,603, Dec. 22, 1917.) Relates to a process and apparatus for wet carbonizing peat, etc., wherein steam is used as heating means. One tube of a battery of tubes is shown. Peat entering is pre-heated in a jacket surrounding a tube and passes along a pipe and through an inlet into an annular space formed between a tube and casing. The tube is heated by steam in a jacket and the casing is heated by steam supplied through a pipe, thereby heating the annular space on both sides. The casing which may have fins is rotated by worm gearing. On leaving the annular space, the heated peat travels through the tube and escapes past a spring-controlled valve.

DRIER FOR PEAT.

Charles D. Jenkins (Can. Pat. 183,582). The drier consists of several communicating and super-imposed cylindrical chambers which are provided with angularly offset inlet and outlet. Each chamber is surrounded by a hot air jacket, the jackets of the several chambers being connected in series. The hot air supply pipe connects with the jackets at one end of the series, whilst the opposite communicates with an air outlet.



which will begin its work with a capital of 2,000,000 crowns (\$536,000). The yearly production amounts to about 15,000,-000 crowns (\$4,020,000). The various peat companies will amalgamate and will receive 75 ore (about \$0.20) for cutting one ton of peat. The company is not to give more than 7 per cent dividend, the rest of the surplus being divided among the owners of the peat bogs in proportion to the quantity of peat delivered.—(Consular Report.)

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Founded at the Jamestown Exposition on October 23rd, 1907. Its object is to further the interest in the uses and application of peat for industrial and economic purposes.

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The Society holds one general meeting per year, and publishes a Journal quarterly, which is sent to all members in good standing. The journal includes the proceedings of the meetings, original papers on practical experience, etc., also abstracts on all contemporary literature and patents, thus all the latest agricultural uses, fertilizer purposes, drainage, fuel, uses, technical uses, etc.

SOME ECONOMICAL POINTS OF INTEREST.

Prof. Chas. A. Davis, U. S. Bureau of Mines, estimated that there are about 12,000 sq. miles of workable peat beds in the United States, outside of the large number of beds very advantageously adapted for agricultural purposes, etc. He gave as a conservative estimate a yield of 200 tons dried peat per acre foot.

Canada has at least 37,000 sq. miles of known peat deposits.

About ten million tons of peat are used in Europe each year.

GENERAL INFORMATION AND INQUIRIES.

All members have the privilege of making inquiries regarding general information about peat and its uses, by addressing the Secretary of the Society.

It must be understood that only general information and of a general character can be given. Members can obtain the names of experts in any special line, from the Secretary of the Society.

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